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NORTHERN CHEYENNE

WATER QUALITY MANAGEMENT REPORT

Prepared for the

Yellowstone-Tongue Areawide Planning Organization

By

The Northern Cheyenne Research Project

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September 26, 1977

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Section 208 Areawide Waste
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TRIBAL COUNCIL OF THE NORTHERN CHEYENNE
NORTHERN CHEYENNE RESERVATION
LAME DEER, MONTANA

RESOLUTION NO. 212 (77)

A RESOLUTION OF THE NORTHERN CHEYENNE TRIBAL COUNCIL PROVIDING APPROVAL OF THE NORTHERN CHEYENNE "208" WATER QUALITY MANAGEMENT REPORT.

WHEREAS, on April 9, 1976 the Northern Cheyenne Tribe signed a contract with the Yellowstone-Tongue Areawide Planning Organization (YTAPO) of Broadus, Montana, to conduct a water quality management study of the Northern Cheyenne Reservation; and,

WHEREAS, a draft copy of this report has been completed, reviewed and suitably modified by the Tribal Natural Resources Committee; and,

WHEREAS, the Northern Cheyenne "208" Water Quality Management Report is a step toward developing a comprehensive water resources management plan for the Tribe; and,

WHEREAS, the Northern Cheyenne Tribal Council, in its contract with the YTAPO, stipulated that it will have final approval and authority over all plans directly affecting the Northern Cheyenne Reservation prepared by the YTAPO and will act as the managing agency for all such plans; now,

THEREFORE BE IT RESOLVED that the Northern Cheyenne Tribal Council hereby approves the Draft Northern Cheyenne "208" Water Quality Management Report, dated September 26, 1977, and authorizes the report to be submitted to the YTAPO in fulfillment of the contract.

PASSED, ADOPTED AND APPROVED by the Northern Cheyenne Tribal Council by 11 votes for passage and adoption and no votes against passage and adoption this 26nd day of September, 1977.

Joe Bear
Allen Rowland, President
Northern Cheyenne Tribal Council

ATTEST:

Norma Wolf Black
Norma Wolf Black, Secretary
Northern Cheyenne Tribal Council

WATER QUALITY SUMMARY

Northern Cheyenne Reservation

A summary of water quality problems and opportunities of the Northern Cheyenne Reservation follows in an attempt to place both on and off-reservation needs in perspective.

ON-RESERVATION

On the reservation, it is felt that upgrading existing pond water quality and planning future ponds to prevent degradation is a high priority. The small ponds and reservoirs are of such great value for both livestock and recreation use that the Tribe should make special efforts to improve and maintain high quality pond waters. In most cases this means preventing direct stock use of ponds and providing off-pond stock watering facilities.

Upgrading sewage treatment lagoons in Lame Deer and Busby, and installing a new treatment system for Birney Village is another high priority. These growing reservation communities require new or expanded waste treatment facilities both to protect public health and water quality values in Lame Deer Creek, Rosebud Creek, and the Tongue River.

Non-point source sediment pollution of Lame Deer Creek is a relatively serious problem from unpaved streets in Lame Deer. Public safety and water quality considerations require that the Lame Deer street system be improved, paved, and curb and gutter installed.

As the reservation population grows and moves out into the countryside with new home construction there is an increasing need for a coordinated tribal land use planning effort. Tribal members need a selection of both community and rural homesites with adequate wastewater

systems and in locations that do not conflict with the real needs of ranching, forestry, agricultural, or future tribal resource operations.

If the Northern Cheyenne Tribe ever decides that any strip mining for coal is to occur on the reservation, special surface and ground water concerns would need to be addressed. Preliminary soils testing indicates that certain areas, such as around Logging Creek, could be difficult to revegetate and reclaim. Detailed reclamation studies and Tribal reclamation codes and regulations would be required if mining were to occur.

If any more exploration drilling is to occur on the reservation, it is recommended that proper hole plugging techniques be utilized to prevent groundwater mixing and aquifer contamination. The Tribe may wish to consider requiring practices recommended by the YTAPO 208 Report.

In summary, there are few severe or widespread water pollution problems on the Northern Cheyenne Rerservation. The pond and sewage treatment related water quality problems can be corrected by the Tribe with timely financial and technical assistance from existing agencies. The economic, recreational, and natural values of the Tribe's water resources are for the most part, still intact. Application of the water quality management recommendations contained in this report will help correct existing problems and prevent future ones.

OFF-RESERVATION

It is felt that the most serious threat to the Tribe's water resources is that from on-going and proposed energy related development in the Tongue River and Rosebud Creek drainages. Most future major economic development plans by the Tribe would rely of necessity on surface water or groundwater

from these two streams. Already, the 750 acre Tribal Irrigation Project requires good quality Tongue River water for its sprinkler system. A number of individual Indian farm and ranch operators either irrigate now or plan to do so. Aesthetic, spiritual, and natural values placed on these streams by tribal members are also threatened by energy development and associated growth.

The Tribe is currently engaged in a water rights litigation that seeks to reaffirm its rights to surface and ground waters flowing on, under, and adjacent to the reservation. While such action will take several years of thorough consideration by various experts and the courts, little is being done to ensure that the water will be of sufficient quality for the uses the Tribe wishes to make of the water. For the Northern Cheyenne Tribe, any water quality degradation of Tongue River or Rosebud Creek potentially harms or limits their present and future uses of these most precious water resources.

In spite of all the energy and water related studies in the Powder River Basin, there is not one source the Tribe can rely on for an indication of what the cumulative impacts of all planned mining and power plant development will be on water quality and quantity. The 208 Water Quality Management responsibilities in the Powder and Tongue River Basins were divided among two seperate 208 agencies in Montana and one in Wyoming. There is a seperate Powder River Basin regional environmental impact study for Montana and Wyoming. None of these studies covered the entire Tongue River Basin nor went into the detail necessary to address specific water quality impacts. Other more detailed individual energy development impact studies are quite site specific.

As a result, no one can yet make a reasonable estimate of just how many strip mines can be located in the Tongue River Valley or how much

combined consumptive use by power plants, agriculture and people upstream can be allowed before the river's salt concentration is too high to use for sprinkler irrigation on Cheyenne lands.

In its review of this report, the Northern Cheyenne Tribal Council emphasized that it views questions such as these as posing the greatest threat to the quality of the Tribe's water resources. With its approval of this report, the Tribal Council has committed itself to managing the improvement and maintanence of water quality on the Northern Cheyenne Reservation. It hopes and expects the states of Montana and Wyoming will do the same to preserve the water quality values of the Tongue River and Rosebud Creek drainages.

INTRODUCTION TO NORTHERN CHEYENNE

208 WATER QUALITY REPORT

The Northern Cheyenne Tribe is greatly concerned with protecting its precious life-giving water resources. The Northern Cheyenne Research Project (NCRP) has been directed by the Northern Cheyenne Tribal Council to establish the present quality and quantity of the Cheyenne's water resources and develop plans to protect the water quality. In response to these assignments the NCRP with the approval of the Tribal Council has joined with the Yellowstone-Tongue Areawide Planning Organization (YTAPO) to develop the specific water quality management needs of the Northern Cheyenne Tribe.

The Northern Cheyenne Research Project is an ongoing research effort which operates under the direction of the Northern Cheyenne Tribal Council and the people of the Northern Cheyenne Tribe. It does not function as a part of, nor is it controlled by, the Bureau of Indian Affairs. Its principal purpose is to assess in depth, the potential impacts to the Northern Cheyenne land and people resulting from proposed energy development on and near the reservation. The Tribal Council established the NCRP in 1973 and it is one of the first tribally controlled research projects in existence. The Tribe has received grants to operate the NCRP from the Office of Native American Programs in the U.S. Department of Health, Education and Welfare; The U.S. Environmental Protection Agency, and formerly the Old West Regional Commission.

The Northern Cheyenne Tribe signed the 208 contract with YTAPO and is submitting its draft report with the following understanding. "It is mutually understood and agreed that this contract is not intended to waive or prejudice in any matter claims by the Northern Cheyenne Tribe to tribal sovereignty and jurisdiction over the Northern Cheyenne Tribal Reservation, and further that the Northern

Cheyenne Tribal Council will have final approval and authority over all plans directly effecting the Northern Cheyenne Reservation prepared by the Yellowstone-Tongue APO and will act as the managing agency for all such plans."

The Northern Cheyenne 208 report is a regional segment of the larger Yellowstone-Tongue 208 report in that it addresses several specific water quality issues of importance on the Northern Cheyenne Reservation. The specific areas that the Northern Cheyenne 208 report addresses are:

a) Sewage treatment facility planning for reservation communities,

b) Small pond and reservoir water quality,

c) Water quality in relation to potential mined land reclamation,

d) Community and land use planning for water quality, and

e) Baseline hydrologic and water quality data.

In most other water quality planning areas, the YTAPO report encompasses the Northern Cheyenne Reservation sufficiently.

The Northern Cheyenne Tribe will be utilizing this 208 report and ongoing work by the NCRP and other organizations to develop a comprehensive water resources management plan for the reservation.

Community Wastewater Facilities Inventory

Five public sewage treatment facilities exist on the Northern Cheyenne Reservation. All are two or three cell facultative lagoon systems that serve from 80 to 1350 people. Several systems actively discharge effluent to surface waters, while the others lose effluent to subsurface seepage and evaporation. The primary sources of information concerning these facilities comes from the Indian Health Service which provided all the funds and technical assistance and the Northern Cheyenne Utilities Commission in Lame Deer which currently administers all facilities. An assessment of the lagoon systems on the reservation was presented in the "Water Quality Inventory and Management Plan, Middle Yellowstone River Basin, Montana", by the Water Quality Bureau of the Montana Department of Health and Environmental Sciences, 1975. Additional data for this report have been collected by the 208 staff of the Northern Cheyenne Research Project (NCRP).

BUSBY

The sewage disposal system for the community of Busby consists of gravity mains and a 2-cell lagoon. The two cells total about 3.0 acres in surface area. This system serves a maximum population of 468 residents and includes 54 children in the Busby School dormitories. An undetermined number of households in Busby are on private disposal systems. At times there is no discharge due to seepage and evaporation. For some periods, there is effluent discharge from a pipe that extends from the lagoons to Rosebud Creek. Measurement of influent and effluent flow rates in March, 1977 were the same, 14 gallons per minute. Busby's population has been gradually increasing and it appears the present lagoons may no longer be

TABLE 1

NORTHERN CHEYENNE WASTEWATER FACILITIES

AVERAGE COMMUNITY DISCHARGES FOR 1976 - 77

	TYPE OF FACILITY	TYPE OF DISCHARGE[1]	RECEIVING WATERS	EPA PERMIT NO. AND EXPIRATION DATE	DESIGN POPULATION	1976 POPULATION	FLOW MGD	FIVE-DAY BOD milligrams per liter IN	OUT	LBS. PER DAY	% REMOVAL	TOTAL SUSPENDED SOLIDS milligrams per liter IN	OUT	LBS. PER DAY	% REMOVAL	FECAL COLIFORM /100 ML	milligrams per liter NO_3	PO_4	pH
BUSBY	2-cell lagoon	I	Rosebud Creek	Application has been made	300	468	0.02	220	43	7	81	158	8	1	95	—	—	—	8.2
MUDDY CLUSTER	2-cell lagoon	ND	—	None	100	80	—												
LAME DEER	3-cell lagoon	C	Lame Deer Creek	MT. 0023141 12-31-78	1000	1350	0.28	235	46	52	81	1080	13	9	98	<100 to 70,000	8	2	7.2
ST. LABRE	2-cell lagoon with Ashland	ND	—	MT. 0022985 12-31-78	1200	329	—												
ASHLAND CLUSTER	2-cell lagoon	I	Tongue River	none	140	93	—	no data	for	the	intermittant	discharge							
BIRNEY VILLAGE	septic tanks	—	—	—	—	84	—												
National Secondary Treatment Requirements for Effluent								Maximum 30 milligrams per liter monthly average and 45 milligrams per liter weekly average. Minimum reduction of 85%.				Maximum 30 milligrams per liter monthly average and 45 milligrams per liter weekly average. Minimum reduction of 85%.				Maximum fecal col- [illegible] 200/100 milliliter on monthly average & 400/100 milliliter on weekly average.			[illegible]

1. I - Intermittant
ND - Non-Discharging
C - Continuous

large enough to store enough winter flow or lose enough to evaporation and to seepage so that the system does not discharge. The additional water loss through evaporation during warm months usually precludes most or all discharge.

As long as the Busby system discharges during winter months, it will likely not meet EPA secondary effluent standards, in particular, fecal coliform and biochemical oxygen demand (BOD). The system's overall impact on Rosebud Creek, however, is relatively small because of the low rate of discharge (14 gpm) in comparison to average stream flow (about 17 cubic feet per second (cfs) average annual flow near Busby). It's greatest impact is likely on winter low flows which range from 7 to 20 cfs.

Monthly chemical analyses and several coliform analyses during 1976 and 1977 above and below the lagoon outfall failed to indicate any substantial impact on water quality from the lagoon system or Busby in general. In addition, Rosebud Creek carries a fairly high suspended solid load (400-700 parts per million (ppm)) and dissolved solid load (20-700 ppm).

MUDDY CREEK HOMESITES

The sewage disposal system at the Muddy Creek Homesites consists of gravity mains and a small two-cell lagoon. The total surface area of the lagoon system is about one acre. The system is servicing a population of about 80 people. Losses from the lagoon are such that all the liquid evaporates or percolates into the ground. There is no pollution problem expected from this percolation, thus, the system is nondischarging. Fecal coliform sampling of Rosebud Creek on July 13, 1976 above and below the lagoon system showed a higher count above the lagoons than below. This was due either to fecal coliform of animal origin or an unrepresentable sample.

Funding for this facility was under PL 36-121, administered by the Indian Health Service. If at some future time, a waste discharge permit is needed, it will be issued under the National Pollutant Discharge Elimination System (NPDES) permit program.

LAME DEER

The sewage disposal for Lame Deer consists of gravity mains and a three-cell lagoon system. The surface area of the first two cells is about 4.8 acres and that of the third is about 5 acres. The three cells are intended to be operated in series. This system serves a population of about 1350. Assuming that 1 acre of lagoon surface will adequately serve 100 people, the Lame Deer system is operating at or above capacity at present. An undetermined number of households within Lame Deer remain unserviced by the public sewer system and utilize various types of on-site disposal methods.

Sampling results of influent and effluent show relatively efficient treatment of the waste load. One reason behind this is apparent ground water inflow to the lagoons. The Indian Health Service engineer reported that two large springs were discovered seeping ground water to the lagoons. The average sewage influent flow rate was figured to be 50 gpm while the lagoon discharge rate is 200 gpm. On this basis, 75% of the discharge is ground water contributed directly into the lagoons.

Even with this dilution effect however, the present lagoon system is not consistently meeting EPA secondary effluent standards of 200 fecal coliform/100 milliliters (ml) and 30 milligrams per liter (mg/l) Five-day BOD. The high infiltration rate means that winter flows cannot be fully stored and the resultant discharge at times is high in fecal coliform organisms. Fecal coliform testing of Lame Deer Creek in March, 1977 re-

sulted in 70,000 colonies/100 ml in the effluent and 92,000 colonies/100 ml 100 feet downstream from the outfall. Other fecal coliform tests have given 200 colonies/100 ml above the outfall and less than 10 per 100 mls below the outfall. These widely varying results are probably caused by the limitations of sampling accuracy and likelihood of sporadic introduction of fecal coliform of animal origin. Five-day BOD levels in the effluent appear generally to meet the standard, however, one test in September, 1976 resulted in a BOD_5 of 64 mg/l. All suspended solids tests have given values far below the standards.

Monthly water sampling results of Lame Deer Creek during 1976-77 upstream and downstream from Lame Deer showed significant differences in water quality (See section entitled "Community and Land Use Planning for Water Quality). Parameters such as sodium, chloride, sulfate, total dissolved solids (TDS) and conductivity, were measureably higher at the sampling point about one-quarter mile downstream from the town and lagoon outfall. For example, average TDS above Lame Deer was 622 ppm while below Lame Deer TDS averaged 719 ppm. Average TDS of the lagoon effluent was 887 ppm for three samples. With an average effluent discharge rate of 200 gpm or 0.45 cfs, the effluent comprised about 20% of the average flow in Lame Deer Creek of 2.64 cfs. At low flow times, the effluent comprised at least 36% of the resultant streamflow.

Much of the increase in TDS in Lame Deer is not caused by the sewage lagoon. Many seeps and springs contribute ground water of higher dissolved solids content to the creek within Lame Deer. During low flows, the entire flow of the creek becomes influent to the ground water and disappears beneath the surface. Just above the Highway 212 bridge the stream reemerges in a marshy discharge area. At the point Lame Deer Creek empties into

Rosebud Creek it is of similar or slightly better quality than the Rosebud which averages about 800 ppm TDS.

ST. LABRE MISSION

The community of Ashland, just east of the reservation, and the St. Labre Mission complex participated in the joint financing of a new sewage treatment facility. The new two cell lagoon system was completed in the fall, 1976 just north of Ashland. Sewer mains and service lines were also installed during the latter part of 1976. Private hookups to the new system are taking place on an individual basis in Ashland when customers pay their hookup fees. At present, two of three possible lagoon cells are constructed and ready for operation. The system is designed to be non-discharging. The third cell will be added if additional capacity is needed to avoid discharge to the Tongue River.[2]

Although the old lagoon system was operating under a NPDES permit from EPA, the operator reported that it never actually discharged to the Tongue River. As of May 1977, the Mission had already started utilizing the new system. One lift pump is in operation that carries wastewater from the St. Joe and Cheyenne Village areas to the trunk line. The other lift station to convey wastewater from the northwest area of the Mission is not yet in operation. The effluent is discharging into the old lagoons. These lagoons are being emptied into the new trunk line and lagoon system. The operator estimated that by fall, 1977, the second lift station would be working and the old lagoons filled in and leveled.

Annual operating and maintenance assessments to the Mission and Ashland for the new lagoon system will be based on the proportion of wastewater flow contributed by each during the previous year. The trunk

lines from the Mission and Ashland both are metered. The sewer line from the Mission to the lagoons is an eight inch diameter force main.

For design purposes of the new treatment system, the Mission's contributing population was estimated to be about 1200.[3] This number includes students, teachers, and other day time only population on the Mission grounds. The Northern Cheyenne Tribal Census of 1976 found the Mission area resident population and Ashland Indian population to be 256. There were six Indian households in Ashland, which at 4.5 persons per household, amounts to about 27 people. This places the resident Mission population at about 229. The new Ashland lagoon system is 18 acres in size and was designed to accommodate some degree of growth anticipated from energy related development. It should provide adequate capacity for the Mission for some time to come and can be expanded in the future if necessary.

In March, 1977 the Guild Arts and Crafts plastics factory on the Mission grounds ceased operations. It formerly employed over 60 persons and would have been serviced by the new sewage system.

There have been six homes built through Housing Authority projects immediately west of the Mission grounds. These homes utilize private sewer and water systems. While these homes and future units built in the immediate vicinity could feasibly be hooked up to the Ashland-St. Labre system, several institutional problems exist. First of all, these adjacent areas are not included in the sanitary district. The issue of district extension is within the jurisdiction of the district Board of Directors. Secondly, there are no long term agreements between the Northern Cheyenne Housing Authority and St. Labre Mission for sharing sanitary services. Each Housing Authority home must be able to be financed and purchased separately by individual homeowners. Finally,

there is little available land left close enough to the Mission system upon which additional homes could be built and potentially serviced by that system. However, the possibility for cooperative agreements between Tribal agencies and off-reservation entities for wastewater treatment should be considered if the need arises.

ASHLAND CLUSTER

The sewage disposal system for Ashland Cluster on the Northern Cheyenne Indian Reservation near Ashland consists of gravity mains and a two-cell lagoon. Funds for this system were provided by the Public Health Service. The total surface area of the two cells is approximately 1.4 acres. This system serves a population of about 80 people in 15 households. The two lagoons are operated in series. The system discharges occasionally to the Tongue River, while losing effluent to subsurface seepage and evaporation most of the time. The DHES water Quality Inventory reported that the sewage disposal system appears to be of sufficient size to provide for the needs of this housing development. To ensure secondary treatment the report recommended that possibly another cell be constructed to provide three cells operated in series and a chlorination unit to be installed to disinfect the effluent. This system did not appear to discharge effluent throughout the first eight months of 1977.

Several new Housing Authority homes built near Ashland Cluster were not connected to this treatment because they were over 250 feet from the sewer line and would have insufficient flow to keep the extension line flushed and unplugged.

Constraints of steep topography and private land ownership may allow few, if any, more new homes to be constructed in areas serviceable by this system.

Birney Village is a community in the southeastern corner of the reservation, situated along the Tongue River. The village area proper has a population of 84 persons. Birney is currently served by a public water supply system but no public sewer system. All homes are on individual septic systems. Plans are under way to construct a sewage lagoon system to serve Birney residents.

This system has been funded by the Indian Health Service and construction is scheduled to begin in early 1978. IHS engineers are in the process of preparing design specifications for the waste treatment system. Tentative plans indicate that it will be a 2-cell lagoon system, designed to be non-discharging. Design is made difficult due to inadequate gradients for sewer lines and rough "breaks" topography in the area near the Tongue River. The Northern Cheyenne Utilities Commission, IHS engineers and tribal land use planner are coordinating planning and design efforts.

COMMUNITY WASTEWATER PROJECTIONS AND NEEDS

Waste water treatment needs on the Northern Cheyenne Reservation are dependent on three principal factors: a.) existing inadequate facilities, b.) population growth on the reservation, and c.) future land use patterns. Reservation treatment needs are prioritized by community in the following discussion.

LAME DEER

Plans are underway to construct a new sewage treatment lagoon system for Lame Deer. The existing lagoons are located on land that has been designated for construction of a new high school complex. The unavailability of this land because of the lagoons has already delayed construction funding of the new high school. Therefore, relocation and construction of a new treatment system for Lame Deer is of the highest priority even without water quality considerations.

The present Lame Deer lagoon system appears to be consistently meeting suspended solids effluent limits and usually meeting effluent BOD limits of 30 mg/l and 85% reduction. The effluent is not consistently under the 200 fecal coliform/100ml monthly average however, particularly in the winter months. The ground water seepage into the lagoons make it impossible to store the entire winter volume which amounts to about 40 acre feet of sewage influent and 120 acre feet of ground water. The present lagoons may store up to 100 acre feet. Effluent must be discharged year-round resulting in high fecal coliform loads in winter months.

Plans and specifications for a new two-cell aerated lagoon system have been prepared by the Indian Health Service. The availability of IHS construction funds for the work however, is uncertain.[4] The new lagoons would be constructed approximately 2.5 miles north of Lame Deer and

discharge to Lame Deer Creek one-half mile above its confluence with Rosebud Creek. This location means that sewer main will be lain through almost two miles of farmland north of Lame Deer. The site was one of the only parcels of tribal land available, the remainder of the intervening land being in private ownership and unavailable. While the capital cost and potential land use conflicts are certainly adverse factors and raise serious questions, the constraints of land ownership and topography may leave little choice.

The new facility is planned to handle a flow of 133,000 gallons per day (gpd) and a BOD load of 437 lbs. per day. This compares to a present flow of about 72,000 gpd and a BOD of 100 to 180 lbs. per day. Thus the facility could handle almost twice the present flow and waste load.

The vendor for the aeration system claims his systems will meet all EPA standards, including 95% BOD removal, 30-45 mg/l suspended solids and 200 fecal coliform/100 ml. Given that the present Lame Deer system cannot always meet the 200 fecal coliform/100 m. standard, consideration should be given to chlorinating the effluent, especially since the system is designed to discharge year round. Funding for this equipment would normally come from the Indian Health Service, and its possibility is unknown at present.

IHS engineers proposed a new secondary sewage treatment facility for Lame Deer as an alternative. The Northern Cheyenne Utilities Commission felt that lack of a qualified plant operator and high operation and maintenance costs and problems made this alternative undesireable. The lack of available land for a lagoon system near town should allow this alternative to receive further consideration.

Throughout the summer and fall of 1976, a land disposal system for

Lame Deer waste water was considered as an alternative. Several Indian Health Service, Bureau of Indian Affairs and tribal organizations participated in the discussions. The basic plan was to store sewage effluent in a reservoir and use it to irrigate cropland in the Lame Deer valley north of town. NCRP 208 staff assisted in the calculation of water availability for irrigation and the acreage needed. A water sample of the sewage influent was analyzed for chemical suitability. Short reports on both topics were prepared for tribal and agency use.

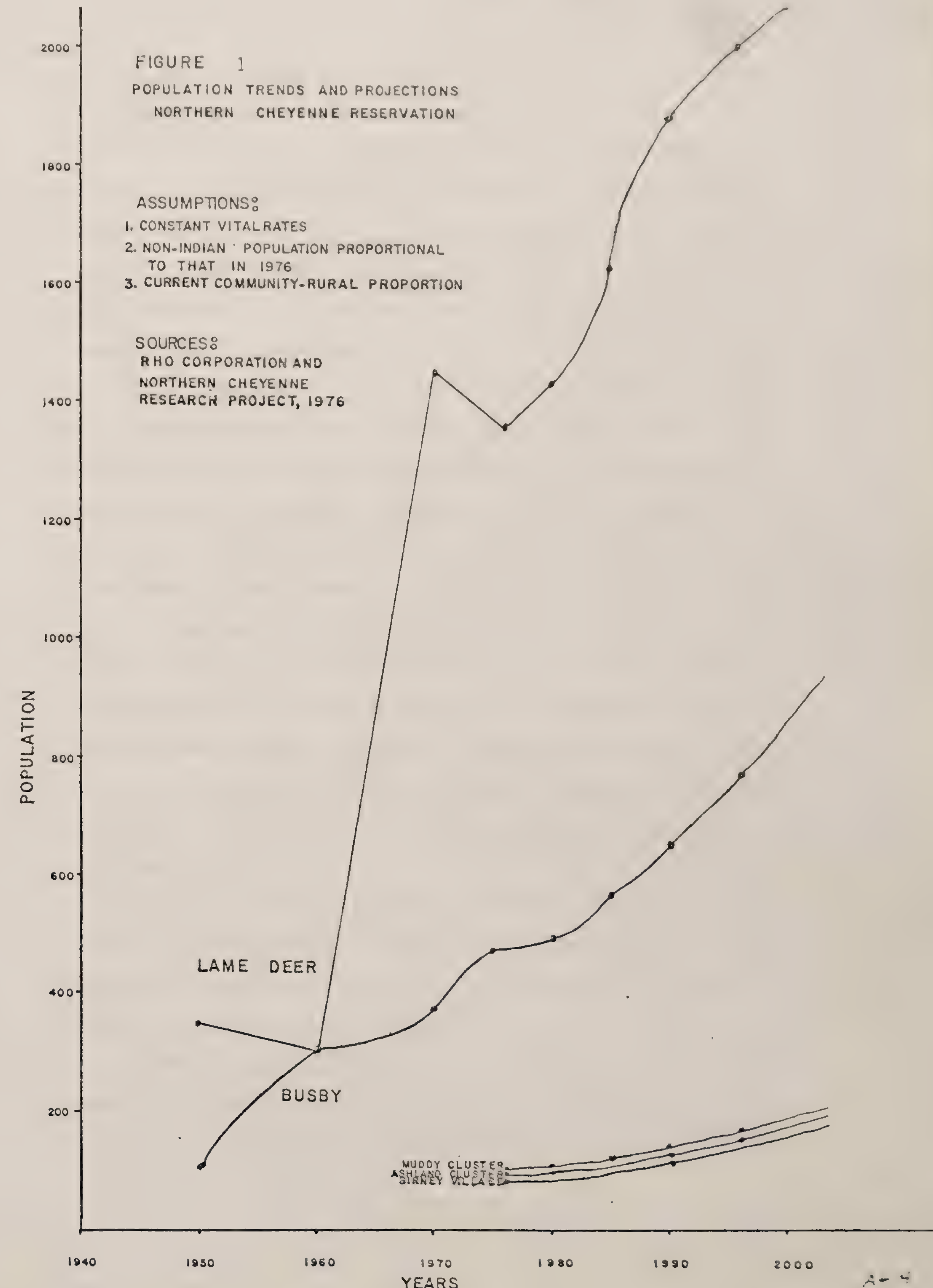
The land application alternative does not appear feasible at this time due to lack of available land for wastewater application. All but one parcel of farm land down the valley from Lame Deer is in private ownership. It was felt that no appropriate long term lease of private land could be arranged. The 36 acre parcel in tribal ownership is about 2.5 miles north of Lame Deer and already has at least two-2½ acre homesites planned for it.

There is some uncertainty over the current per capita rate of water usage in Lame Deer. Water meter records indicate average flow delivered to the community is about 100,000 gpd. The Northern Cheyenne Utilities Commission bills about 300 households for water service in Lame Deer. At an average of 4.5-5 people per household (i.e., 1350 to 1500 population), this is 67 to 74 gallons per person per day (GPCD). The most recent census conducted in Lame Deer[5] gave a population of 1357 persons in 380 households. A number of these households, perhaps as much as 10%, are not serviced by public sewer. These figures would imply a water use rate of 75 to 85 GPCD. Since the recent census was judged to be relatively accurate, it would seem wise to use a planning figure in the higher

range. The other main assumption is that 70% of the water used by the community gets back into the sewer system. If this percentage is higher then the population that can be served by a certain design flow is diminished proportionately.

Population projection figures presented in Figure 1 indicate that under normal growth rates, Lame Deer could be expected to increase from 1350 to 2000 people by the year 1996. The new facility appears capable of handling a population of 2500 at the current water use rate of 75 gallons per person per day. That population level could be reached sometime beyond the year 2000. These population projections assume a continuation of present vital rates of birth, survival and death. They also assume that non-Indians will comprise the same percentage of the total population as in 1976. The projections, in effect, do not consider any large influx of energy-related growth on the reservation. Given the uncertainties over the magnitude of energy related growth in the region and on the reservation, it appears unwarranted to plan for facilities much larger than the one designed. The lagoon system should be designed so as to allow installation of additional lagoon cells as a buffer against unexpected population increases or higher water use rates.

Future land use development is a third important factor affecting wastewater treatment needs. Lame Deer experienced a four to five-fold increase in population from 1960 to 1970 along with much new home construction. Construction of approximately 15 single family dwellings on the southwest side of Lame Deer is currently in progress. The projected population increase from 1976 to 1996 in Lame Deer, would demand an additional 145 new dwelling units. Much of the current new home construction demand is filled by families wanting to upgrade their housing situation or move to a more desireable location.



A new B.I.A. Realty contract has been let to locate, survey and plat approximately 100 new homesites in Lame Deer that would be serviced by public sewer. These subdivisions will likely be located mainly on the west and southwest sides of town. Sewer extensions have already been made to service other recent development in those two directions.

Quite a list of other new facilities are underway or planned for construction in Lame Deer:

FACILITY	LOCATION	STATUS
New PHS Clinic	Northeast Side	Completed
New Elderly Home	Northeast Side	Ground Work Underway
Tribal Building Expansion	At Existing Site	Completed
I.A.P. Building Expansion	Northeast Side	Ground Work Underway
New High School	Northeast Side	Two Years Away
Community College	Northeast Side	Ground Work Underway
New Juvenile Center	West Side	Two Years Away

Of this list, it is likely that only the new high school and community college may make significant waste load contributions in addition to the basic population projections. The other facilities primarly involve expansion or replacement of old structures.

It is questionable that the same rapid rate of population growth that occurred in the 1960's can continue. Two principal factors are already constraining growth within Lame Deer. There is a strong trend to rural locations in new home construction. People are preferring to get out in the countryside, even though they may work in Lame Deer. Since 1967, 318 homes have been constructed in the five reservation communities, 199 of those in Lame Deer, while 233 have been constructed in rural areas. Most of the homesites in the latest Housing Authority project consisting of 66 units are planned for rural areas.

The other major constraint is one of land availability due to topography limitations and private ownership. Lame Deer is located in an

alluvial valley, one-quarter to one-half mile wide and bounded by steep hills on both east and west sides. Townsite expansion to the north, northeast, and south is constrained by farmland in private ownership. Sites for most new homes and public facilities are located primarily on tribally owned land since it can be aquired through lease at little or no cost. Little money exists for purchase of private land by either the tribal government, public agencies or private individuals on the reservation. There is a tribal land acquisition program that purchases land in the name of the tribe. Several lots have been purchased within Lame Deer. While purchase of land immediately adjacent to Lame Deer for expansion would be desireable, the possibility of this is unknown until additional funding sources are explored and willing sellers found.

Several public sewer and water line extensions are being planned by Indian Health Service in Lame Deer. The first one is a 1200 foot extension to service the Spotted Elk Heights area. Work is to commence in summer of 1977. This extension would service an area already platted for homesites and fill a service gap between an area further up the valley that is already serviced. The Spotted Elk Heights area does have several older and new homes, but is largely undeveloped. Approximately 65 lots are platted, however, a number of these are already occupied or have access blocked.

Another sewer and water extension planned for summer, 1977 is from the elderly housing complex, 600 feet, to the northeast lagoon. Some opportunity for future hookups exists on a five acre parcel of tribal land just north of the elderly complex.

The IHS engineer in Lame Deer indicated that another application for funds for 3000 feet of sewer and water line extension has been made to IHS. The locations for line extensions under this project will be deter-

mined in part, by the results of the surveying and mapping contract being administered by the NCRP and surveyed and staked by a contractor with the 3,000 foot line extensions as part of the criteria. Priority areas at this point include a small parcel of tribal land just north of the elderly complex, a northeast extension of the Crazy Head Heights area, a westward extension of the Beverly Hills area, and parcels of tribal land southwest of Lame Deer.

A map of Lame Deer including possible housing areas and sewer line extensions is shown in Figure 2.

BIRNEY VILLAGE

After the new Lame Deer facility, the Northern Cheyenne Tribal Council and Utilities Commission have placed a priority on installation of a sewage lagoon system at Birney. All 22 occupied homes are currently on individual disposal systems and there have been problems with the operation of some of the septic tanks and drain fields.

Indian Health Service funds for this new system have recently become available with construction to start in 1978.[6] The lagoon system is being designed to serve most existing homes and other potential homesites currently being surveyed and platted under an ongoing tribal contract. Although the lagoon site and design is still being formulated by IHS engineers, it appears likely that the system would be non-discharging. As is the case with the Muddy Cluster and Ashland Cluster lagoons, the relatively low rate of influent flow and high evapotranspiration rates plus seepage could combine to eliminate any surface discharge to the Tongue River. Preliminary site evaluations have turned up few, if any, good lagoon sites. A site to the southeast of town along the Tongue River appears most feasible.

FIGURE 2

PROPOSED SEWER LINE EXTENSIONS IN LAME DEER, MONTANA

Birney has generally lost population in recent years due to people moving into other reservation communities. Based on their 1976 census and numerous personal interviews, the NCRP sociology staff feels that Birney will probably remain near its current population level of 84 for several years to come. Population projections indicate that under normal growth rates, Birney could reach about 130 by 1996.

Land use developments hold the greatest potential for affecting Birney's future. The MONTCO coal and power consortium backed by Pacific Northwest utility firms and the ITT Corporation plan to open a coal strip mining operation directly across the Tongue River from Birney. Coal exploration firms are currently conducting geologic and environmental studies on the site. A tentative mine start-up time has been forecasted for 1981. Should this come about, the increased employment opportunities or service related business opportunities could attract many more people, both Indian and non-Indian, to Birney. The potential impacts of this neighboring development indicate that any wastewater treatment facility be designed with flexability and ease of expansion in mind. IHS engineers indicate that an aeration system could be added to the lagoons if more treatment capacity is needed.

BUSBY

The Busby sewage lagoon system deserves consideration for upgrading because it occasionally discharges substandard effluent to Rosebud Creek and is currently servicing more the the 300 persons it was designed for.

Population projection trends presented in Figure 1 indicate that under normal growth rates, Busby could grow from 468 currently to about

770 by 1996. These projections are reasonable forecasts of growth under current vital rates and a similar proportion of non-Indian residents. However, they do not account for high rates of immigration that could be associated with energy related development in the area. When and where this development could occur is only speculative at this time.

Land use trends evidence Busby as continuning to be a growing community. In the last ten years, approximately 80-90 new housing units have been built in Busby. A number of those, of course, are replacement units. Population projection figures indicate that Busby could expect an additional 70 housing units by 1996.

An additional impetus to further development in Busby could be the resurveying and plating of the townsite that is to be done during summer, 1977, under a BIA contract to the tribe. Lots and blocks will be surveyed and staked and subdivision plats drawn. This work should considerably enhance the availability of homesites in Busby. Unlike Lame Deer, Busby is surrounded by buildable tribal land.

To better treat existing loads and handle anticipated growth Busby should be considered for a new or expanded three-cell faculative lagoon system. Since land appears to be available, the lagoons could be designed so as to be non-discharging to surface waters. This could prevent the fecal coliform pollution of streams associated with year round lagoon discharges. Funding for an expanded or new treatment system would come from the Indian Health Service. At present, such funds are not available, nor has any application from the tribe been made as yet. An additional option is to study the feasibility of sprinkler irrigation of the effluent on nearby cropland.

Along with an improved treatment system, consideration should be given

to extending a sewer line to service the gas station, store and post office area along the highway. A small hill separates this area from residential Busby and a preliminary engineering analysis by IHS would help establish the fesability of such an extension.

INDUSTRIAL WASTE DISCHARGES

At present, there are no industrial waste discharges on the Northern Cheyenne Reservation. The only factory, Guild Arts and Crafts, on the St. Labre Mission grounds in Ashland, closed down in February 1977. It produced plastic products for the Mission.

The Northern Cheyenne Livestock Association and formerly the Northern Cheyenne Community Development Corporation (CDC) have developed some economic plans that call for future agriculturally related industries such as:

1. A feedlot for 7,500 cattle
2. A meat packing plant
3. A tannery

While these industries are possible and certainly pose potential water pollution problems, they are considered speculative at this time. Preliminary proposals for such facilities have received endoresement by the Tribal Council. Each facility would likely need approval by the Council as it was planned. It is anticipated that, at a minimum, the tribe will require such facilities to meet EPA waste discharge standards. The CDC plan included an animal waste recycling facility to produce useable livestock feed and fertilizer.

The reclassification of air quality on the reservation under the Prevention of Significant Deterioration (PSD) regulations of the Clean Air Act from Class II to I, allows for very little air pollution increase over current levels from the 19 regulated heavy industries. These include coal-fired power plants and gasification plants. Under current technology, it is unlikely that such plants could be located on the reservation and meet Class I air standards. Hence, it is unlikely that wastewater discharges associated with these facilities will occur on the reservation in the near future. The

potential for location of energy conversion facilities upstream from the reservation exists in either the Tongue River or Rosebud Creek basins. While Class I air standards on the reservation may not prevent such facilities from being built, they could affect the type of air pollution control equipment or siting location of proposed sites. Baseline water quality monitoring, such as has been conducted by the Northern Cheyenne Research Project, will aid in detecting any future industrial-related water quality problems.

Recreation Facilities

An additional category of waste disposal needing examination is that related to brief but intensive use of several pow-wow and recreational sites on the reservation. During the Fourth of July Pow-Wow, up to 2000 people may gather on the pow-wow grounds south of Lame Deer. It is not known whether this intensive use of privies in the area adversely affects the local ground water or nearby Lame Deer Creek. However, health and sanitary reason suggest that a permanent restroom facility or portable chemical toilets be used. An advantage of portable toilets is that they could be moved to other site as needed. The Tribal Board of Health may wish to explore the various alternatives and sources of funding.

REGULATORY PROGRAMS

The Northern Cheyenne Utilities Commission (NCUC) is the principal organization charged with administering waste water treatment facilities on the reservation. The NCUC was organized under the authority of the Northern Cheyenne Tribal Council. They determine hookup policies, collect fees for service and maintain the facilities.

The NCUC relies on the Indian Health Service for engineering, design and water testing services. The NCUC operation supervisor and IHS engineer in Lame Deer are responsible for much of the day-to-day troubleshooting and management of the water and sewer systems. They draw up facilities plans and help determine treatment priorities. While everyday treatment needs were being handled, there was often poor communication among the various agencies involved in land use or housing decisions on the reservation.

Since the NCRP 208 and land planning staff commenced work on land use mapping, several meetings were held that brought together most of the principal organizations involved in housing, roads, sanitation, livestock, realty, etc. From one of these meetings, the NCRP was requested to prepare and submit a resolution to the Tribal Council requesting formation of an advisory Tribal Land Use Planning Committee composed of representatives from each of these groups. The resolution passed on February 21, 1977. The Land Use Committee is advisory to the Tribal Land Use Committee which has jurisdiction over most land related problems on the reservation.

The first general meeting was held at which time planning needs and functional duties were discussed. The committee will advise the Tribal Lands Committee on matters of homesite locations, expansion of communities, land use conflicts and planning needs. The NCRP is the technical support group for the committee. The committee will analyze and use the various maps and overlays being produced by the NCRP 208 and land use projects. The committee will provide a means for reservation-wide planning of resource use, housing location and waste water treatment.

It may well be that the existing regulatory powers of the agencies involved are sufficient to provide for adequate planning and prevention of waste water pollution problems. The recently formed Land Use Planning Commit-

tee may provide the communication necessary to facilitate timely and adequate assessment and control of problems. If additional regulatory authority is found to be needed, the Planning Committee may work with the Tribal Lands Committee and Utilities Commission in developing the best approach to the problem. Proposed regulations could be submitted by the Lands Committee or the Utilities Commission to the Tribal Council where final approval action would be required to authorize and implement any new regulations, statute or code. Regulations or guidelines adopted in this way could be implemented directly by any tribal organization or be submitted to other government agencies such as the BIA or IHS for implementation.

Increasingly, however, Indian tribes are taking on more of the administrative responsibilites associated with water resource or land use management. The Constitution of the Northern Cheyenne Tribe allows it to adopt plans, regulations and programs that protect and manage its natural resources and general welfare. These could include land and water management plans and codes.

SOCIAL AND ENVIRONMENTAL IMPACTS

This part of the 208 plan for the Northern Cheyenne Reservation makes no structural recommendations for facilities that will not eventually be done by the Indian Health Service and Utilities Commission as time and money permit. The recommendations previously mentioned are ones of increased institutional communication and the development and use of better technical information for land and water management.

The environmental impacts of this plan are not structural or disruptive. Possible additonal cost could be involved in adding chlorination units to wastewater treatment systems or in constructing lagoons so as to

be non-discharging. The 208 recommendations for sewage treatment will be reviewed and modified as needed by both Tribal and governmental agencies such as the Indian Health Service. Planning for adequate treatment systems now, that will meet water quality standards will prevent additional problems and costs at a later date. The plan stresses sound land and water planning so its largest impact may be in guiding the location and timing of houses, facilities, etc., which would be built anyway.

The social impact will be determined by how effectively the organizations involved, Tribal Council, Land Use Planning Committee, NCRP and others, inform and involve the residents of the reservation. Changes in housing policies, zoning, water use, etc., must stem from the Tribal Council and its committees and be given the necessary time and public exposure for review and modification.

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PONDS AND SMALL RESERVOIR WATER QUALITY ON THE
NORTHERN CHEYENNE RESERVATION

[illegible] AS A [illegible] RECREATION RESOURCE

The Northern Cheyenne Reservation contains numerous small ponds and reservoirs. Most are small man-made impoundments that trap spring snow melt and storm runoff or springs that emerge downslope from clinker hillsides. The principal use of most small impoundments is for summer livestock watering. However, six of the major reservoirs are also used extensively for recreational activities, such as fishing, swimming, picnicing, etc. The general location of these ponds is shown in Figure 1.

Table 1: Principal Multi-Use Ponds on the Northern Cheyenne Reservation

	Water Acreage
Redrose Pond	7
Parker's Pond	20
[illegible]	6
Lost Leg Pond	6
Greenleaf Pond	1
Crazy Head Spring Ponds	5

As future recreational demands as well as cattle watering and irrigation needs for water increase, so will the need for multi-purpose ponds and reservoirs. A considerable portion of the total water requirements for the reservation can be satisfied through utilization of smaller bodies of water. This form of development is most adaptable to the Northern Cheyenne Indian Reservation. A general description of each of the six major multi-use ponds follows.

1. Redrose Reservoir

Redrose reservoir is located two miles west of the town of Busby off U.S. Highway 212. The pond is stocked annually by the U.S. Fish and Wildlife Service (FWS) with catachable size rainbow trout. The pond covers seven acres and is big enough for canoeing. It has an access road leading into the pond area from Highway 212. The pond lies within allotted and undivided interest lands.

The reservoir lies within the drainage of Ash Creek, a tributary of Rosebud Creek flowing onto the Northern Cheyenne Reservation from the Crow Reservation. Gently rolling terrain and open grassland characterize the drainage area.

This pond was constructed in the mid-1960's under the direction of Lyman Brewster of the Bureau of Indian Affairs and funded by the Agriculture Stabilization and Conservation cost share program.

2. Parker Pond

Parker Pond is about 20 acres in size and is located 3½ miles southwest of Busby on State Highway 314. The pond is privately owned and lies within allotted land. It is open to fishing with permission of the owner. The pond was stocked several years ago with northern pike and bluegill sunfish. The establishment of a self-sustaining pike population currently provides good fishing. A dike rings most of the pond and large willow trees make some shoreline recreational uses difficult. One portion of the pond is devoted to use by farm livestock and the pond could be used for irrigation of adjacent fields.

The pond lies within the drainage of Davis Creek, a tributary of Rosebud Creek flowing onto the Northern Cheyenne Reservation from the Crow Reservation. Gently rolling terrain and grassland or farmland characterize the drainage area.

The pond was contructed in the mid-1960's under the direction of Lyman Brewster of the Bureau of Indian Affairs and funded by the Agriculture Stabilization and Conservation cost share program.

3. LaFever's Pond

LaFever's Pond is about 6 acres in size and located 5½ miles southwest of Busby off State Highway 314. The pond is privately owned with public fishing permitted since it is stocked annually with catchable trout by the FWS. LaFever Pond also support a good largemouth bass fishery which is maintained by natural reproduction. The pond is currently used for livestock water purposes with potential for some irrigation use.

The pond lies within the drainage of Thompson Creek, a tributary of Rosebud Creek flowing onto the Northern Cheyenne Reservation from the Crow Reservation. Open rolling terrain and pine covered hills characterize the drainage area.

This pond was constructed in the mid-1960's under the direction of Lyman Brewster of the Bureau of Indian Affairs and funded by the Agriculture Stabilization and Conservation cost share program.

4. Lost Leg Lake

Lost Leg Lake, located 14 miles south of Lame Deer off Lame Deer-Birney Highway 315, is located in a very attractive little valley surrounded by ponderosa pine. The pond suffers from excessive seepage. There is an access road to the reservoir from the highway, but is nearly impassable when wet. The pond is stocked with catchable rainbow trout by the FWS. The pond consists of two acres of water and is located on

tribal land. This area holds good potential for a commercial campground, and is used in summer for camping by various groups. The pond is currently used for stock watering.

The drainage area consists of approximately 200 acres at an elevation of approximately 4000 feet. A grassy valley and pine covered ridges characterize this watershed.

The pond was built in the mid-1960's under the direction of Gene Thompson of the Bureau of Indian Affairs.

5. Greenleaf Pond

Greenleaf Pond, located 13 miles east of Lame Deer on Highway 212, covers one acre with water and has one acre of recreational land surrounding the pond. The pond is stocked annually with catchable rainbow trout. Largemouth bass fry were also planted during the summer of 1976. The site is very near the Ice Wells which have considerable historical interest. Unfortunately, the Ice Wells feature is not in very good repair. A wooden shelter has been constructed around the wells but they contain refuse. The pond and surrounding area is located on original tribal land.

The drainage area consists of high ridges at an elevation of approximately 4000 feet. Forested valleys of rough terrain characterize this drainage at the head of Greenleaf Creek.

This pond was built in the mid-1960's under the direction of Gene Thompson of the Bureau of Indian Affairs.

6. Crazy Head Springs Pond

Crazy Head Springs Ponds, located 10 miles east of Lame Deer, 1½

miles off Highway 212, contains a total of four acres of water in four ponds stocked with rainbow trout. A campground and picnic grounds are available for public use. The ponds are located on tribal land. A 605 acre buffalo pasture on tribally owned land is close by.

Crazy Head Spring, located 600 feet above the first pond, supplies water to the ponds along with supplemental springs in the pond itself. Concurrent overflows from the higher ponds provide water to successive lower ponds. The springs emerge at the base of open grassy slopes and the ponds lie in a narrow timbered valley.

The first pond was built in the mid-1960's under the direction of Gene Thompson of the Bureau of Indian Affairs. The second, third and fourth ponds were funded by the Agriculture Stabilization and Conservation cost share program at the request of the Northern Cheyenne Livestock Association under the direction of Carroll Barber of the Bureau of Indian Affairs.

THE 208 POND SAMPLING PROGRAM

The six ponds just described were the subject of a water sampling program designed to obtain baseline water quality data and identify sources of pollution. The overall objective was to develop recommendations for improving the water quality of existing and new ponds.

Samples were taken once per month, with some exceptions, from May, 1976 through April, 1977. Each pond sample was taken by wading out to at least three feet of water at two or three locations around the pond and forming a composite sample. Samples were taken in the upper three feet of water surface. In the winter, two or three holes were chopped in the ice, about halfway to pond center and samples collected at arm's

depth through the ice. Samples were not filtered or treated in anyway other than to be kept cool and sheltered. Water samples were normally mailed by 4:00 P.M. the same day they were taken and received by the lab within 24 hours.

Field measurements were normally taken of pH, water temperature and conductivity. Measurements of field pH were taken with a Cole-Palmer digital type intrument which occasionally malfunctioned and caused questionable results at times. Measurements of temperature and conductivity were taken with a YSI Model 33 S-C-T meter that generally functioned well. Notes were occasionally made of pond appearance, presence and nature of aquatic vegetation, intensity of livestock use or recreation use.

The water analyses contractor, Yapuncich, Sanderson and Brown Laboratories (now called Energy and Environment Consultants, Inc.) of Billings, Montana conducted all water analyses based on methods approved by "Standard Methods", fourteenth edition.[1] The lab passed several EPA quality assurance tests for the parameters tested for in the 208 sampling program.

Water testing assistance was received from the U.S. Fish and Wildlife Service, Hardin, Montana office. The FWS and NCRP collected dissolved oxygen samples at various depths in Crazy Head Spring Pond #1, LaFever Pond and Parker Pond.

The major limitation of the 208 pond-water sampling program is the lack of more extensive dissolved oxygen and biochemical oxygen demand (BOD) data. This was hampered by not having in-house testing capability and the large distance and time to appropriate laboratories. While loading of ponds with oxygen demanding organic animal wastes is known to

be a significant contributer to pond water quality problems, this could be confirmed with more dissolved oxygen and BOD testing. The development of anaerobic (no oxygen) conditions within bottom waters of certain ponds needs to be better documented. More coliform sampling should be done on a regular basis to determine potential health hazards to swimmers.

WATER QUALITY RESULTS

Pond water analyses results are presented in Table 1, along with recommended standards for fish and livestock taken from the California State Resources Control Board publication, "Water Quality Criteria, 1963."[2] Average constituent concentrations that approach or exceed the reported standards are encircled.

Of the chemical constituents tested, only alkalinity and fluoride levels approach recommended standards for livestock. Alkalinity levels exceeding 170 ppm have caused diarrhea in some animals. Once accustomed to higher alkalinity however, livestock generally are not harmed by the levels found in the ponds sampled. The average fluoride value of 4 ppm found in Lost Leg Lake was boosted by an excessive sample of 28 ppm taken February 16, 1977. All other sample results reported concentrations less than 1.8 ppm. There has been no reported harm to livestock from drinking water containg less than 1.0 ppm fluoride. Above that level, some research results show harmful effects, such as flourosis of the teeth, and other reseach shows no harm up to 100 ppm fluoride. No harmful effects of fluoride have been reported on the reservation, however, certain ground waters have been found to contain above normal levels. While it appears that the likelihood of fluoride injury to livestock from reservation ponds, is low, it is advisable for ranchers to check for symptoms, such as mild

COMPARISON OF AVERAGE [illegible] WATER QUALITY TO SELECTED STANDARDS [illegible] NORTHERN CHEYENNE RESERVATION 1976-77

CHEMICAL CONSTITUENTS (parts per million)	CRAZY HEAD SPRINGS	CRAZY HEAD #1	CRAZY HEAD #2	CHEYENNE	LAMEDEER	LOST LEG	PARKER	[illegible]	RECOMMENDED STANDARDS: FISH	LIVESTOCK
POTASSIUM	4	4	4	4	6	5	11	4	[illegible]	[illegible]
SODIUM	16	15	16	10	25	24	52	34	[illegible]	[illegible]
CALCIUM	[illegible]	49	37	52	[illegible]	29	36	43	[illegible] Fishwaters < 52 ppm	[illegible]
MAGNESIUM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] < 14 ppm	[illegible]
SULFATE	22	18	16	14	[illegible]	25	[illegible]	[illegible]	[illegible]	[illegible]
CHLORIDE	7	5	7	5	[illegible]	5	11	11	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FLUORIDE	1.1	0.9	1.1	0.6	0.4	4	0.25	[illegible]	[illegible]	[illegible]
[illegible]	12	10	11	11	[illegible]	6	5	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	0.03	[illegible]	[illegible]	0.02	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	229	113	[illegible]	243	491	162	555	[illegible]	[illegible]	[illegible]
ALKALINITY	[illegible]	[illegible]	[illegible]	241	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	9	10	7	17	[illegible]	12	12	[illegible]	[illegible]
pH	7.5	7.5	8.4	8.0	[illegible]	[illegible]	8.3	[illegible]	[illegible]	[illegible]
[illegible]	401	[illegible]	433	451	88[illegible]	[illegible]	1292	1264	[illegible]	[illegible]

Source: [illegible] Control Board 1963. Water Quality Criteria. [illegible] and H.W. Wolf, ed.

1. Chemical concentrations are averages of 8-12 monthly samples taken in the upper 3 feet of pond water.

2. [illegible] indicates that the recommended standard may be approached or exceeded for fish or livestock.

3. [illegible] may not be representative due to missed sampling periods or suspected [illegible] errors.

FIGURE 2: SAMPLE LAB ANALYSES REPORT

P O BOX 893 — YAPUNCICH, SANDERSON & BROWN LABORATORIES — 13 N. 32ND ST

BILLINGS MONTANA

LABORATORY REPORT

Lab. No. 12880-8

To Northern Cheyenne Research Project Date 6-07-76

Address 208 Project General Delivery Lame Deer, Montana 59043

WATER ANALYSIS

CHS 1st Pond
Field pH 7.1 Temperature 18°C
Sampled 5-27-76 @ 3:00
Submitted 5-28-76

CONSTITUENT	PARTS PER MILLION
1. Potassium	3
2. Sodium	19
3. Calcium	50
4. Magnesium	24
5. Sulfate	3
6. Chloride	4
7. Carbonate	0
8. Bicarbonate	305
9. Total Dissolved Solids, Calculated	253
10. Total Dissolved Solids @ 180°C	289
11. Standard Deviation of Anion-Cation Balance	-0.78 Sigma
12. Fluoride	1.2
13. Silica (SiO_2)	11
14. Nitrate (NO_3)	<1
15. Total Phosphorus as P	0.1
16. Total Hardness as $CaCO_3$	221
17. Alkalinity as $CaCO_3$	250
18. Non-Carbonate Hardness as $CaCO_3$	0
19. Conductivity @ 25°C	450 micromhos/cm.
20. pH	7.8
21. Total Suspended Solids	1

(< is less than)

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fluorosis, or mottling of the teeth.

Recommended water quality standards for fish were exceeded by those parameters contributing most to dissolved solids and alkalinity, such as magnesium, calcium, sulfate and bicarbonate. High dissolved solids loads are characteristic of most ground waters that contribute water to the ponds. Inspection of monthly dissolved solids or conductivity levels reveals that the lowest concentrations occur in June and get progressively higher until February. This trend coincides with increased surface water runoff containing low concentrations of dissolved solids in spring and early summer, and a greater proportion of ground water inflow, high in dissolved solids, during winter.

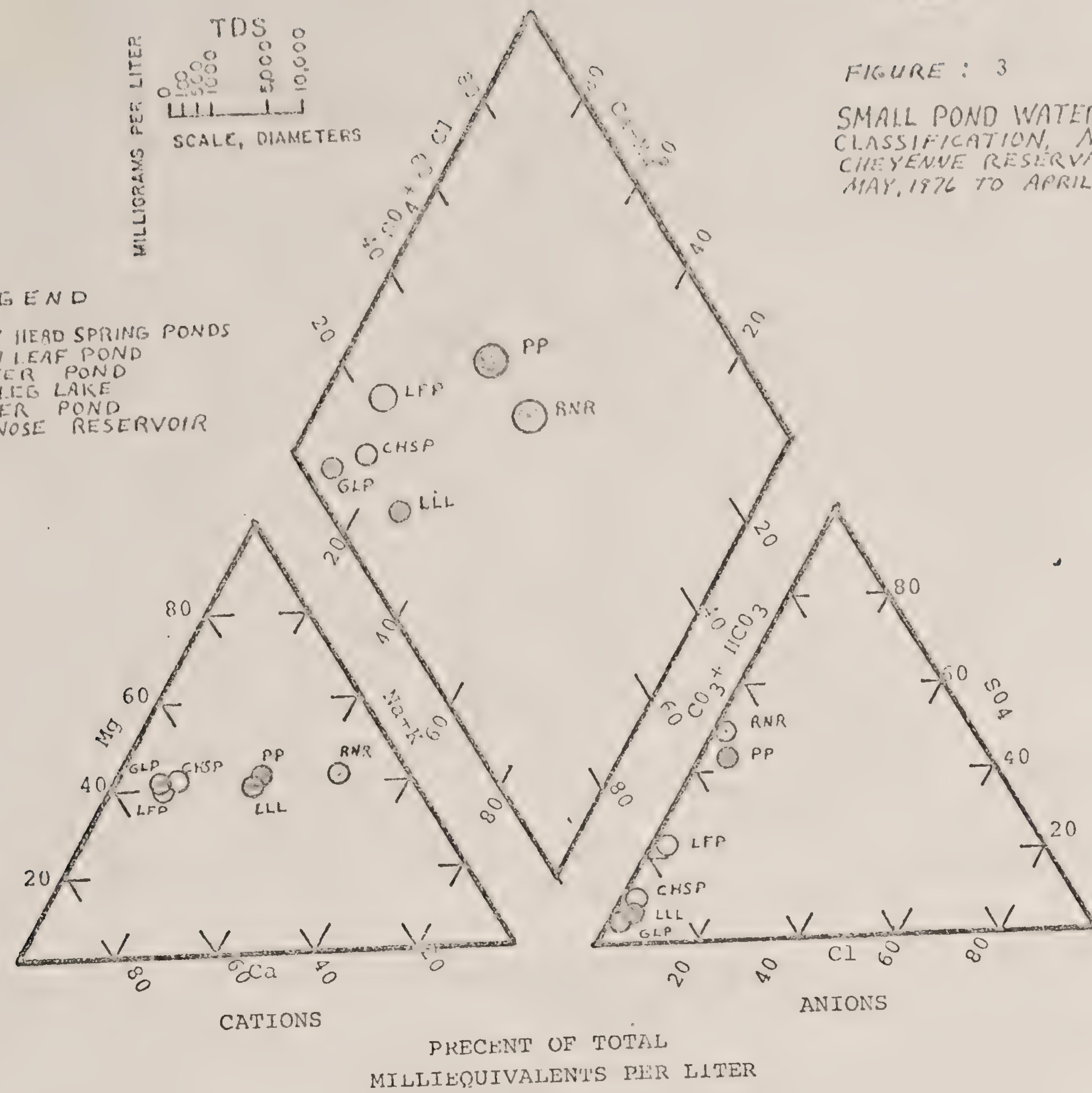
Water quality in the ponds sampled, was classified using a standard Piper diagram (Figure 3). The Piper diagram allows the basic chemical make-up of waters to be classified by their dominant constituents. The four major cations: magnesium, calcium, sodium and potassium determine the position of each pond's circle in the lower left triangle of Figure 3, based on the percent of total millequivalents per liter. The lower right triangle does the same for the four principal anions: sulfate, chloride, carbonate and bi-carbonate. Lines are then drawn from the circles representing the same pond in each triangle to the large diamond shaped figure in the center of the figure. The lines are projected upward and parallel to the tick marks on the sides of the diamond. The intersection of these two lines determine the position of the circle for each pond in the diamond. From the position of each circle in the diamond, the percent dominance of each cation-anion group can be seen on the sides of the diamond. The size of each pond's circle represents the relative average dissolved solids concentration - the larger the circle,

FIGURE : 3

SMALL POND WATER QUALITY CLASSIFICATION, NORTHERN CHEYENNE RESERVATION, MAY, 1976 TO APRIL, 1977

LEGEND

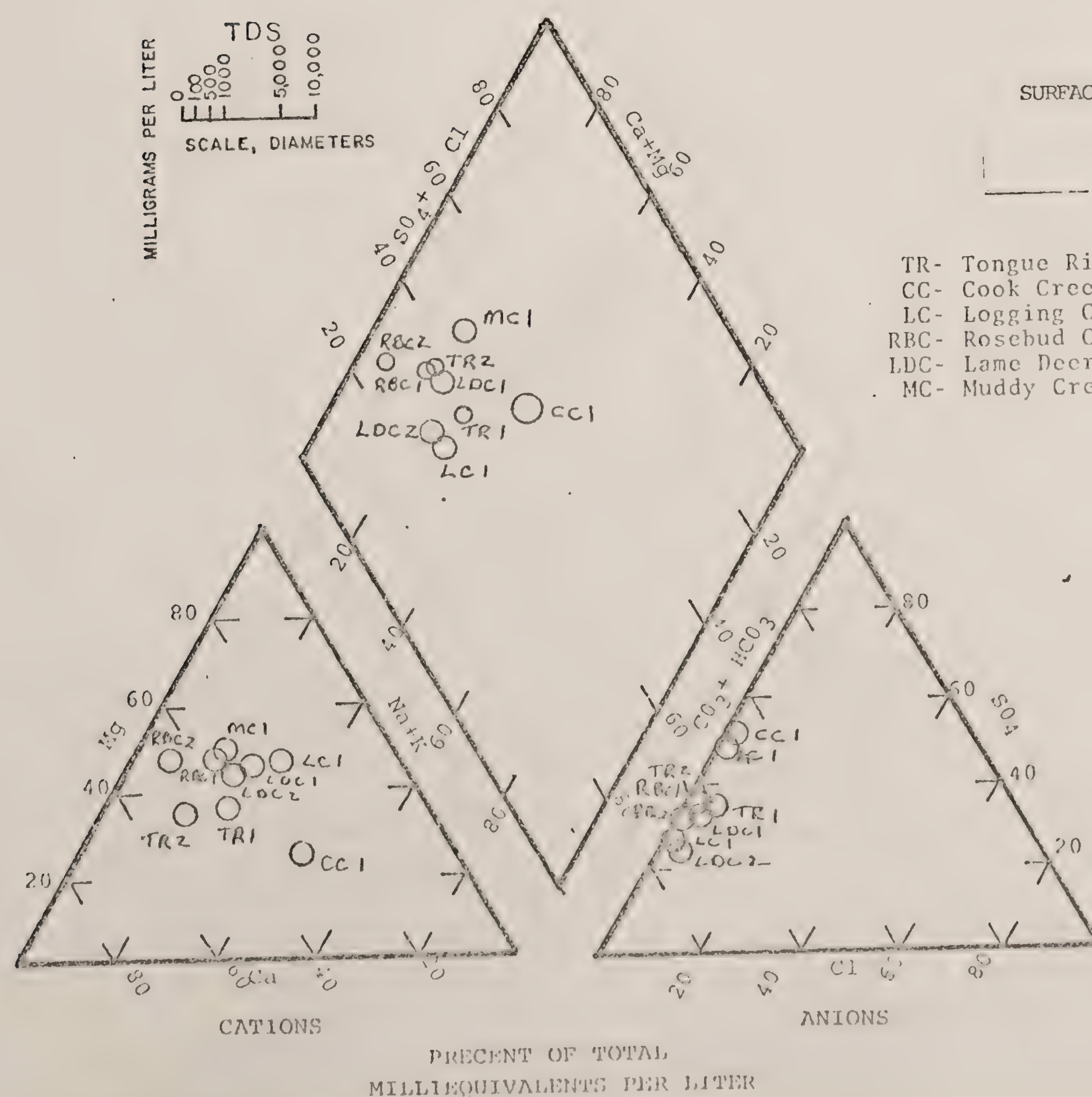
CHSP - CRAZY HEAD SPRING PONDS
GLP - GREEN LEAF POND
LFP - LAFEVER POND
LLL - LOST LEG LAKE
PP - PARKER POND
RNR - RED NOSE RESERVOIR



B-11

SURFACE WATER

TR- Tongue River
CC- Cook Creed
LC- Logging Creek
RBC- Rosebud Creek
LDC- Lame Deer Creek
MC- Muddy Creek



B-12

FIGURE 4 : Piper Diagram Surface Water

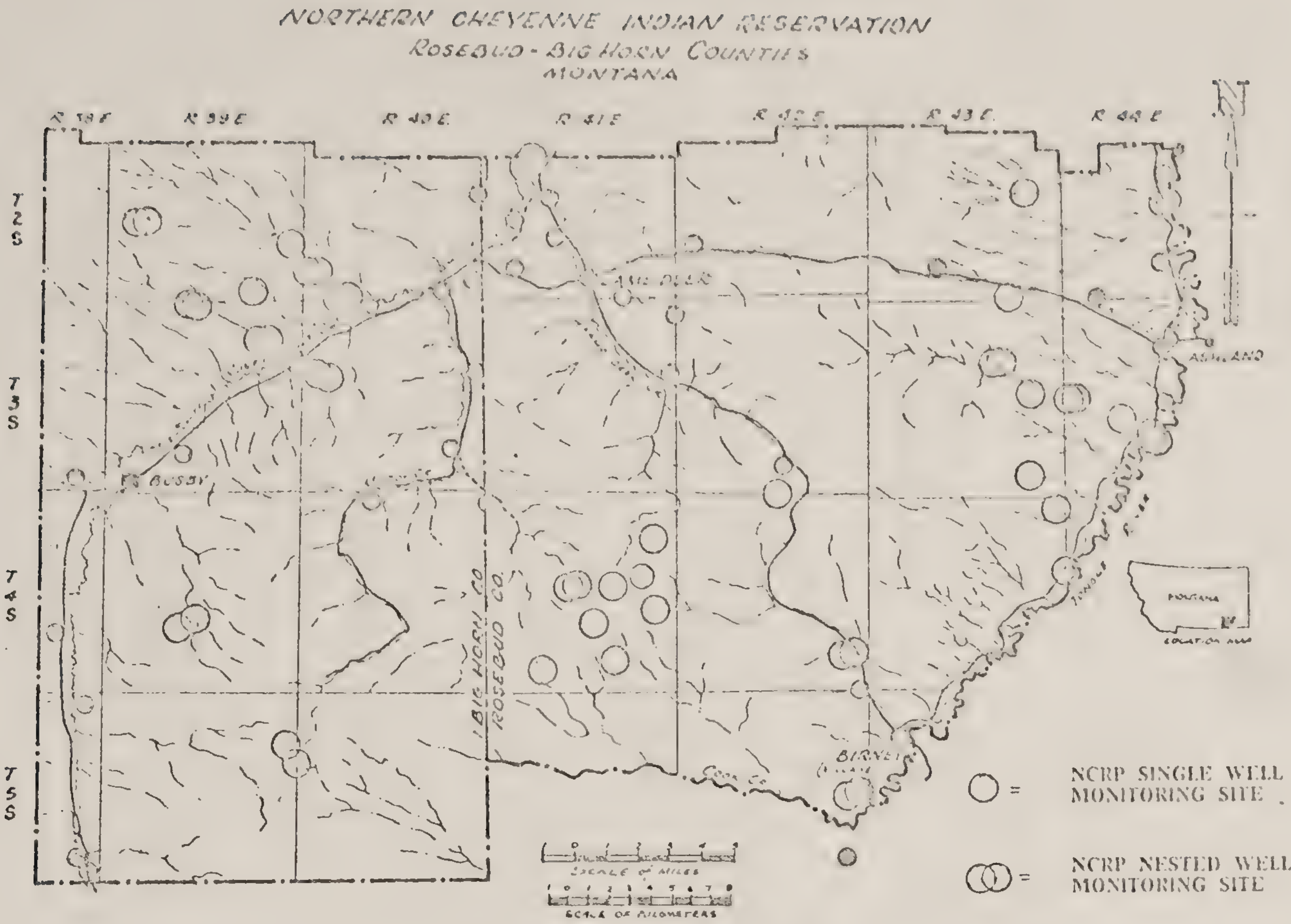
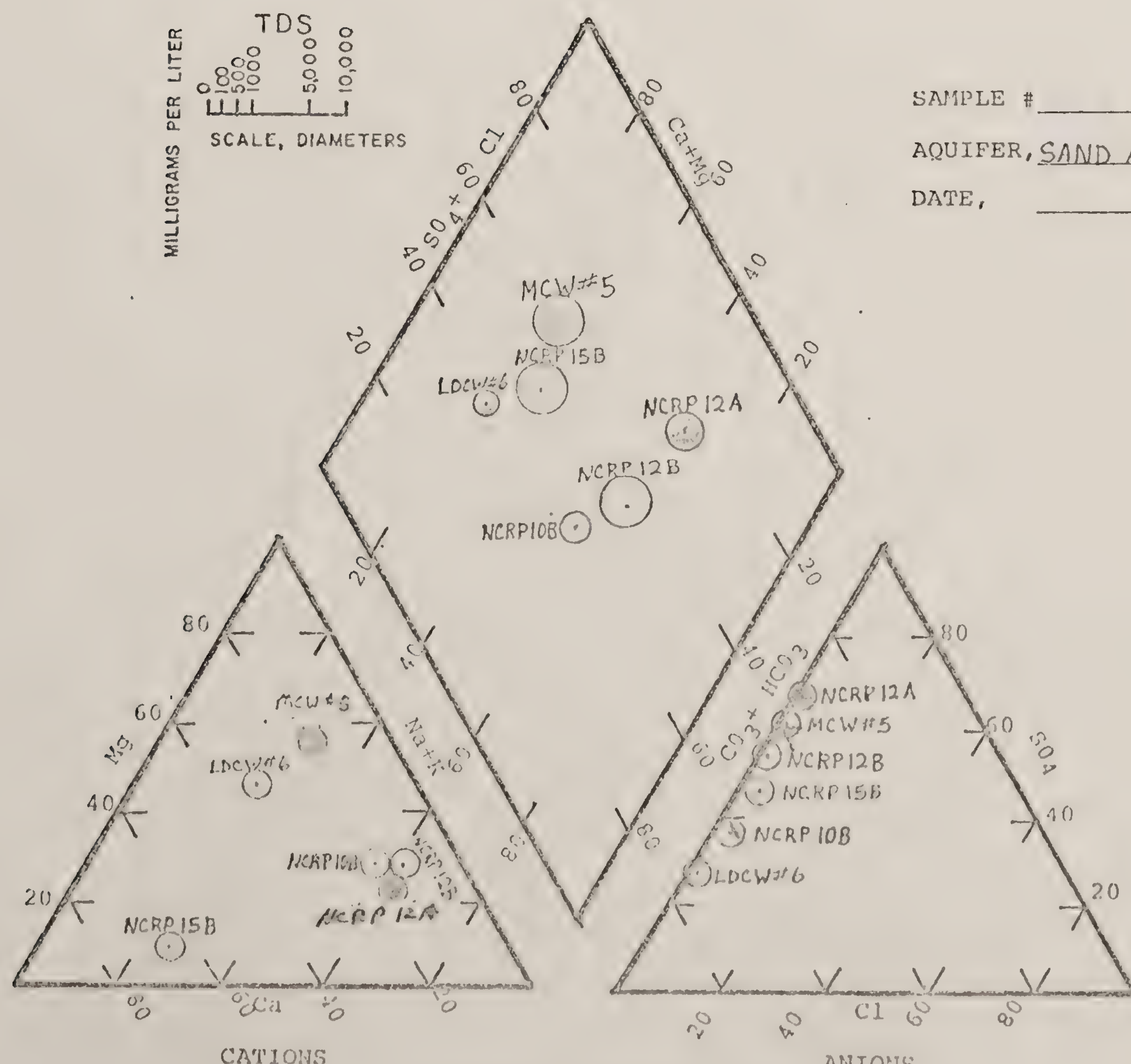


Figure 5

Groundwater Monitoring Stations



PERCENT OF TOTAL
MILLIEQUIVALENTS PER LITER

FIGURE 6 : Piper Diagram Alluvium Aquifers

the greater the average dissolved chemical concentrations of the anions and cations shown.

Waters are either a calcium magnesium-bicarbonate type as in all Crazy Head Spring Ponds, Greenleaf Pond, Lost Leg Lake, and LaFever Pond, or a calcium magnesium-sulfate bicarbonate type, such as Parker Pond and Rednose Reservoir. Piper diagrams classifying reservation surface water and alluvial sand and gravel aquifers are presented in Figures 4 and 6 respectively. Figure 5 shows location of ground water monitoring wells.

Comparison of the diagrams demonstrates that Crazy Head Ponds, Greenleaf, Lost Leg, and LaFever Ponds have water quality closely resembling that of surface waters. The first three ponds are all spring fed from very local ground water systems in fractured clinker. Waters have a short residence time in the ground and little dissolved solids remain in the burned clinker material for leaching. LaFever Pond is fed by Thompson Creek which averages a flow of about 1.5 cubic feet per second (cfs) in the winter and flows 2-6 cfs in the spring and summer. This high rate of surface water inflow is the predominate influence on chemical quality of LaFever Pond. Chemical analyses of Thompson Creek correlates highly with that of LaFever Pond.

Parker Pond is fed by Davis Creek and may be located in a ground water discharge area. Pond and stream water quality correlate very closely. Davis Creek flows an average of less than 0.5 cfs in the winter, and 1-2 cfs during spring and early summer. A higher proportion of Davis Creek is baseflow of ground water from the alluvial aquifer. Hence, water quality in both Davis Creek and Parker Pond more nearly resembles that of the sand and gravel aquifers.

Rednose Reservoir is in the Ash Creek drainage basin which is an ephemeral stream. Rednose is also in a ground water discharge area and its water quality most closely resembles that of alluvial sand and gravel aquifers.

A variety of factors appear to be influencing nutrient concentrations of nitrate (NO_3) and total inorganic phosphorus (P) in the ponds. Crazy Head Spring itself has rather high average nitrate and phosphorus concentrations. Most of the recharge area for this spring is located in pasture land that is grazed extensively by cattle throughout the summer months. Eighteen head of buffalo graze nearby year-round. It appears that infiltrating precipitation may be leaching organic N and P forms from animal wastes in the basin. Oxidation occurs in the interim, and the resultant spring water contains the elevated nutrient levels.

Examination of other NCRP well water data reveal very sporadic nitrate and phosphorus values within wells over time and between wells finished in similar geologic materials. Nitrate concentrations range from less than 0.1 to 13 ppm in shallow wells finished in river valley alluvium, while phosphorus ranges from less than 0.01 to 0.43 ppm. Wells finished deep in alluvial valleys or in lower lying strata have nitrate values of less than 0.1 to 3.0 ppm and phosphorus values of less than 0.01 to 0.26. The only significant trend appears to be that the shallower wells have generally higher nitrate and phosphorus concentrations than deeper wells. Since there should be no N or P sources within the geologic material that there wells were finished in, it leaves the conclusion that the nitrate and phosphorus found in springs and well waters originated from surface sources, primarily livestock. The sporadic nature of N and P concentrations reflect the vagarities in livestock

grazing, winter feeding locations, ground water recharge occurrence, and N and P oxidation-reduction rates.

It is interesting to note that Crazy Head Ponds #1 and #4 contain successively lower concentrations of NO_3 and P as the waters move down through the ponds and stream courses. Average NO_3 concentration was 0.97 ppm in pond #1 and 0.75 ppm in pond #4, while average phosphorous concentrations were 0.09 and 0.05 in ponds #1 and #4 respectively. The water courses immediately below the spring head are choked with cattails, reeds and other emergent and submergent vegetation. This vegetation as well as the algae in the ponds apparently are utilizing N and P to a measureable extent and are removing it from aqueous solution at least temporarily. In effect, the aquatic vegetation and algae serve as a 'biological filter' of nutrients. The fourth pond appears the most turbid since cattle have easy access to all sides for watering. Submergent vegetation is thick whereever there is insufficient depth. For the most part however, the ponds drop off rapidly within 2-4 feet of the shoreline.

After Crazy Head Spring, LaFever Pond had the next highest nitrate level (1.6 ppm). This probably reflects the intensive use of one corner of the pond by geese and hogs. The pond is a multi-purpose reservoir intended for both farm and recreational use. Hogs and geese use the pond in the southeast corner near the dam. The animal use adversely affects water quality in this corner by increasing turbidity and organic waste loading. While at present, the remainder of the pond is of good quality, continued fertilization and organic waste loading by stock use may eventually degrade the water quality and fishing value of the entire pond. One-third of a composite water sample was usually taken in the stock use

area and the higher nitrate value reflects this.

Lost Leg Lake contained the highest average annual total inorganic phosphorus concentration (0.12 ppm). This is mostly attributable to the intensive cattle use of the immediate watershed area and the watering and wallowing of cattle in the pond itself.

WINTERKILL OF FISH

Two ponds, Rednose Reservoir and Lost Leg Lake, have serious water quality problems as evidenced by fish kills of rainbow trout that were discovered in mid-April 1977. The ponds were inspected by NCRP, Indian Health Service, and U.S. Fish and Wildlife personnel and the cause was believed to be winterkill, which is a lethal depression of dissolved oxygen content in the water beneath the ice. Low oxygen levels in ponds develop over winter under ice cover when photosynthesis and wave action, both of which add oxygen to waters, no longer take place. Decomposition of organic matter in the water does occur all winter long and this process uses oxygen. Shallow depth ponds are most severely affected by winterkill because they generally have more aquatic vegetation which is available for decomposition throughout the winter.

Both Lost Leg Lake and Rednose Reservoir are shallow in relation to their surface area. Both, particularly Lost Leg, are intensively used by cattle. The shallow depth and nutrients contributed by livestock combine to produce extensive growths of submerged aquatic vegetation. The decomposition of the organic matter that occurs throughout the winter and absence of sunlight for photosynthetic oxygen production produces low oxygen levels in late winter and can cause the fish kills such as occured on Lost Leg and Rednose Reservoir. Lost Leg, in addition is fed by relatively

small springs and has a seepage problem since it is located in highly permeable clinker material. This results in low through-flow rates and low water levels from late summer through the winter.

Dissolved oxygen samples were taken under the ice and off the bottom in Crazy Head Pond #1 just prior to ice out in April, 1977. While DO was depressed near the bottom neither sample showed dangerously low dissolved oxygen levels. This pond has good depth in relation to its surface area and aquatic vegetation is not a problem.

FISHERIES MANAGEMENT

U.S. Fish and Wildlife Service (FWS) personnel based in Hardin, Montana, have been most directly involved in fisheries management on the reservation. The Montana Fish and Game Department has also stocked fish in certain reservation ponds in past years. BIA Land Operations and tribal personnel in Lame Deer were most often involved in coordinating fish stocking of ponds with USFWS or Montana Fish and Game.

The FWS Hardin office prepares a short annual report concerning fisheries management activities and stocking on the reservation. Their 1976 Annual Project Report indicates that fishery management work on the reservation began in 1964, includes 9 ponds, and 12 miles of stream (Rosebud Creek near Busby). Crazy Head Spring Ponds and Lost Leg Lake are managed solely for rainbow trout. LaFever and Rednose Ponds are also managed for largemouth bass in addition to rainbow trout. Parker Pond is managed for northern pike only. Greenleaf Pond was managed solely for rainbows until 1976 when largemouth bass fry were introduced on an experimental basis. Rosebud Creek has been stocked annually with catchable rainbow trout.

Management activities by the USFWS during 1976 include fishery surveys (by hook and line or gill nets) of Greenleaf, Crazy Head Springs, LaFever, Rednose, Lost Leg and Parker Ponds. They reported that the majority of the ponds surveyed were found to contain good populations of trout. Largemouth bass present in LaFever and Rednose Ponds were found to be doing very well. Rosebud Creek was electrofished at several locations. White suckers were the only fish captured, but problems with electrofishing gear reduced sampling effectiveness.

The fish planting record for 1976 states that a total of 38,200 rainbow trout, 8 to 12 inches in length, and 800 largemouth bass fry were planted on the reservation.

Ron Ulrich, Fisheries Management Biologist with the USFWS in Hardin is working on a preliminary fisheries management plan for the reservation. The plan will outline long range fisheries goals and projects. Water quality data from the 208 project was provided to the FWS to assist in the development of the plan.

Many tribal members enjoy fishing in the ponds. The tribe receives some additional income from the sale of fishing liceses to non-tribal members. Tribal fishing permits are required of non-tribal members for any fishing on the reservation.

SWIMMING

Most of the large reservation ponds are used to some extent for swimming. The ponds used most frequently include Crazy Head #1 and #4, Greenleaf, Lost Leg Lake and Rednose Reservoir.

Acceptable waters used for swimming must generally be: a) free from obnoxious floating or suspended substances, objectionable color

and foul odors, b) they must contain no substances that are toxic if ingested or cause irritation to the skin, and c) they must be reasonably free from pathogenic organisms. Various standards have been set by state agencies for acceptable coliform organism levels in swimming waters. They range from a median value of 50 coliform colonies per 100 ml to no more than 2400 coliforms per 100 ml average for any one day's samples. One widely accepted criterion establishes that the arithmetical mean coliform density not exceed 1000 coliforms per 100 ml and that this concentration not be exceeded in more than 20 percent of the samples in any one month.

Of the above mentioned ponds, Lost Leg Lake and Rednose Reservoir are not wholly acceptable from the stand point of being free from nuisance algae and weeds. Lost Leg Lake in particular, can be used for swimming only in the early summer, until the floating plant mats become too thick. To a lesser extent, Rednose Reservoir contains growths of emergent and submergent vegetation which makes wading difficult and can entangle the swimmer. These problems are caused by a combination of relatively shallow depths, livestock use, minimum water supply to the ponds, and excessive seepage.

Although some previous coliform testing of the ponds has been done by Indian Health Service personnel, there have been no permanent records maintained. NCRP 208 staff ran a fecal coliform test on Crazy Head Pond #4 on July 13, 1976. The results indicated no fecal coliform colonies developed and gave the total colony count as less than 100 per 100 mls of sample. Other coliform testing on Lame Deer Creek, Rosebud Creek and Tongue River resulted in total coliform counts of 40 to over 100 per mls of sample and fecal coliform counts of 10 to 680 per 100 mls. Due to

the sporadic nature of coliform occurance and potential sampling errors, a large number of samples should be run on a single pond over a definite period such as one day, week or month. On the reservation, this would have to be undertaken by IHS, since only they have in-house coliform testing capability.

The Public Health Service clinic in Lame Deer reported in June, 1977, that as far as they know, there have been no reported illness or skin irritation attributed to swimming in waters of any reservation pond. Several cases of shiegella have occured, but were not correlated with swimming in reservation ponds.

POND LIMITATIONS

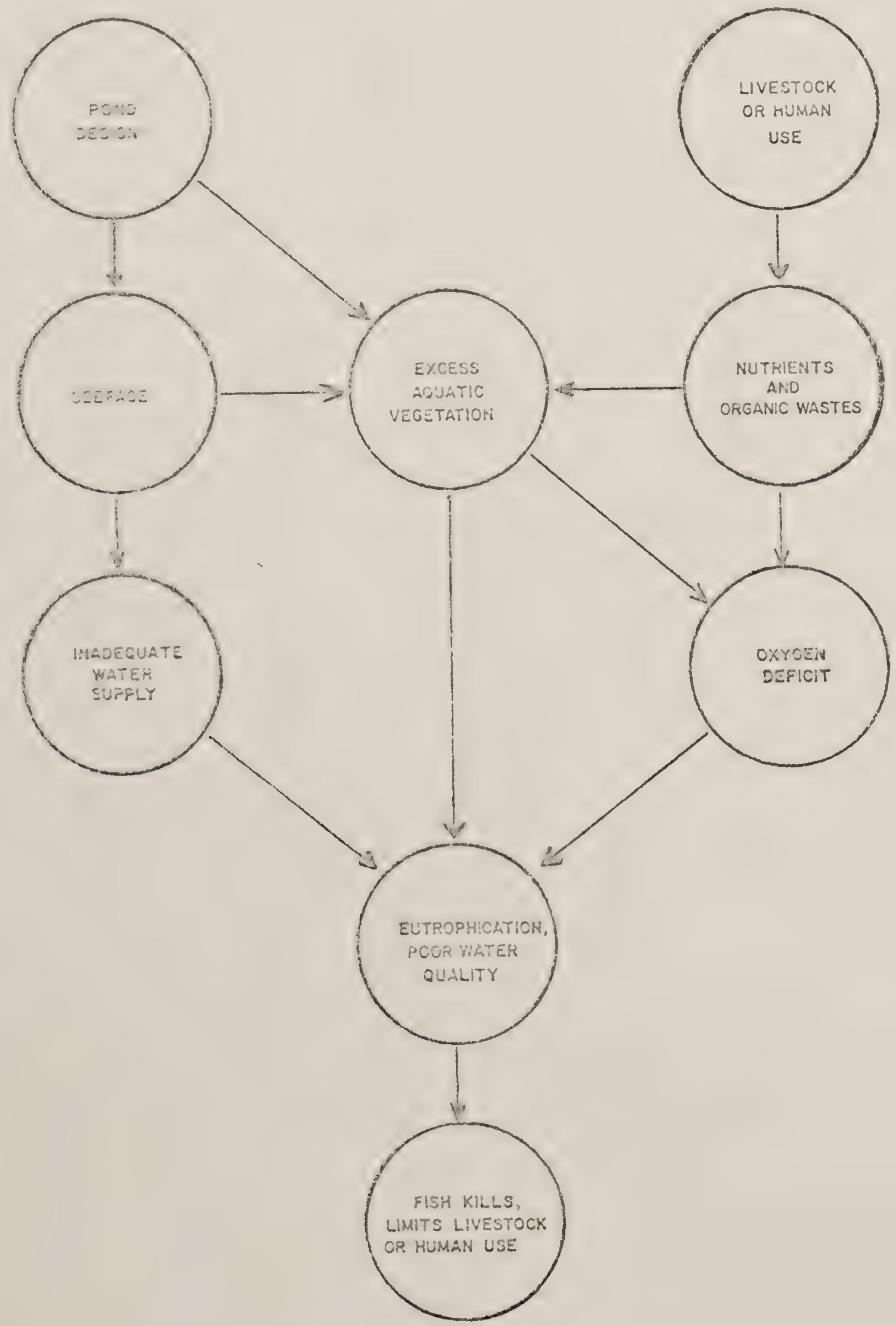
The major problems of the various ponds and reservoirs on the reservation which are directly or indirectly related to one another are as follows:

a) excessive nutrient and organic waste loading from livestock,
b) inadequate water supply from ground water or surface water sources,
c) excessive vegetation growth in ponds, and,
d) poor pond or reservoir design and excessive seepage.

Figure 7 shows the relationship of these pond limitations.

Once the major pond water quality limitations are understood, existing pond problems can be evaluated and solutions proposed. Care should be taken to properly locate and design future ponds. The recommendations that follow are based on the pond water quality problems identified in the 208 program. The recommendations are separated into two categories: (a) general recommendations for new ponds and improving existing ponds, and (b) specific recommendations for improving existing ponds.

FIGURE 8 ___ POND LIMITATION RELATIONSHIPS



GENERAL RECOMMENDATIONS FOR MULTI-USE PONDS

The first question asked when a new reservoir site is proposed is usually, will it hold water? The question is a simple one but coming up with the right answer gets complicated. To determine if a planned reservoir will eventually fill up, the amount of water entering and leaving the proposed reservoir must be considered. Figure 8 shows the principal factors which affect the rate of filling and whether the pond will hold enough water.

Some factors affecting the water supply in a pond include:

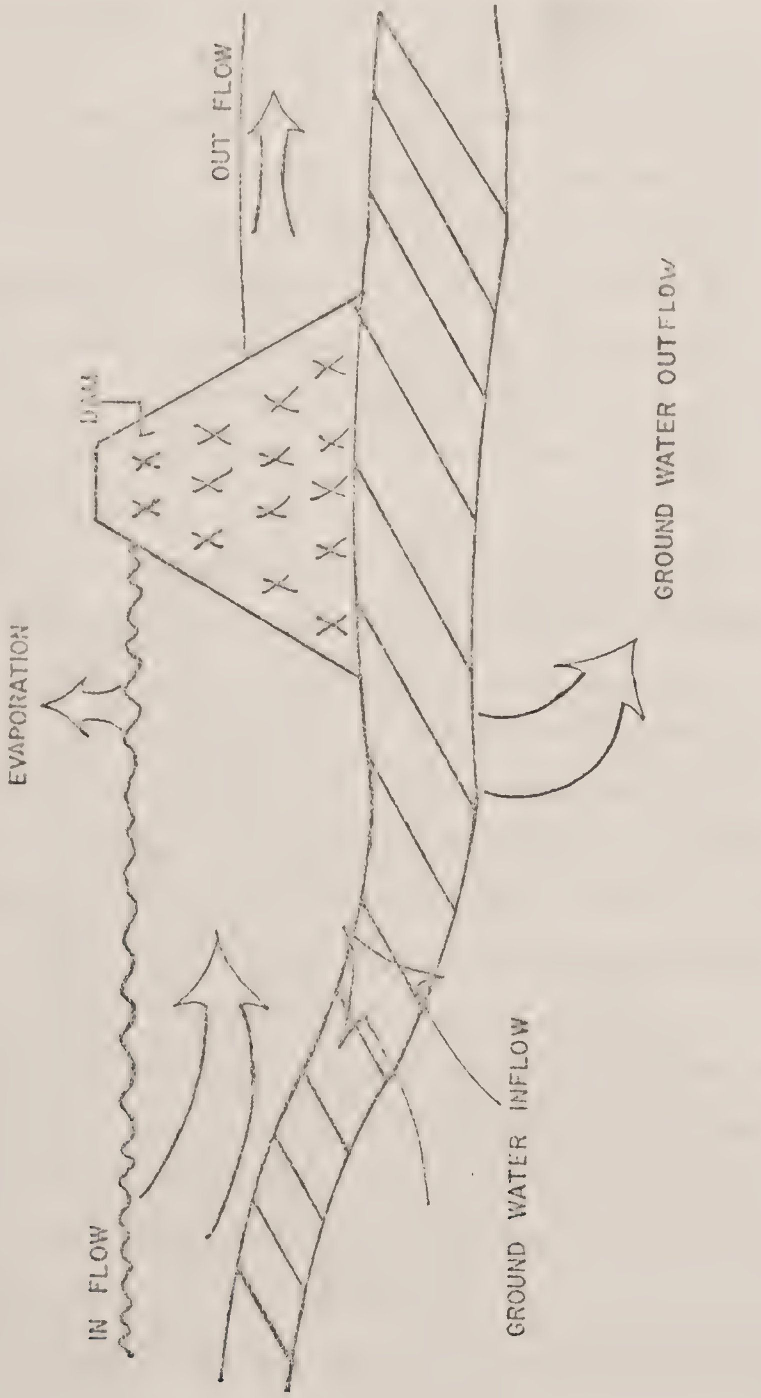
1. Soil Layer—Will the soil in the bottom and in the dam allow for a large or small seepage loss? Will the soil have to be artificially prepared with betonite and how much is needed if seepage is to be reduced?

2. Streamflow---Is the streamflow constant and greater than the amount of water lost through seepage and evaporation back to the air? If so, how fast will the reservoir fill? If not, can the reservoir be redesigned?

3. Ground Water--Is there ground water which will be added to the reservoir or will a deep water table encourage water to seep out of the reservoir?

4. Dam--Will the dam be properly constructed to hold water? Will it wash out when spring melt or rainstorms occur?

FIGURE 8 PRINCIPAL DAM FACTORS



The previous questions only addressed if the reservoir will have water in it. The next question which should be asked is what the impoundment is to be used for? If they are truly multi-purpose the uses many include: 1)swimming, 2)fishing, 3)cattle watering, 4)irrigation. Each of these uses requires additional information needs as reservoir design is developed.

1. Swimming--The reservoir must be of sufficient depth and have a firm bottom to be safe. The water quality must be free of harmful chemicals or organisms which could affect a user's health.

2. Fishing--The reservoir must be at least 10 or more feet deep to provide good habitat and protect the fish from winterkill. The species of fish planted in the ponds are controlled by the water quality, amount of oxygen in the water, water temperature, habitat and natural spawning potential. The U.S. Fish and Wildlife Service will provide technical assistance on design and construction of impoundments intended for fishing.

3. Stock Watering--Cattle usually need 6 to 12 gallons of water per day so the larger the reservoir the more cattle could be serviced. The use of actual reservoirs for watering, however, can conflict with the clean, good quality needed for recreational use. A carefully designed watering place below the dam could best serve the cattle and minimize water quality damage and nuisance plant growth in the main reservoir.

4. Irrigation--The irrigation potential of proposed reservoir sites will depend on reservoir size, water quality and the availability of irrigable land near the reservoir site.

Two additional factors must be considered. First, in estimating water requirements one must total the needs for each purpose and be sure

that there is a supply adequate for all the intended uses. Second, make sure that the purposes for which the water is to be used are compatible. Some combinations such as irrigation and recreation may not be compatible. Heavy water use during the irrigation season for example, could make boating and swimming impractical. Each pond may be best suited to different uses. For example, ponds at Broken Jaw Coule on the Pow-wow Grounds would certainly be in high demand for recreational uses like swimming, picnicing and fishing. A pond on Fillwright Spring may be more needed for stock watering, It may be helpful to decide what the main two or three uses of each pond will be, and to design for those uses.

In designing small multiple use ponds for the purpose of fostering fish wildlife; to increase the recreational facilities on the reservation; to create opportunities for irrigating croplands; to provide livestock watering places, the following general recommendations of the NCRP and U.S. Soil Conservation Service should be considered:

1. Vegetation Water Ways--A separate water course and small depression may be excavated as an off-shoot from the main pond for stock watering uses. Water preferably flows from the first pond to the stock area and the first pond is fenced and protected from direct livestock use. The water course is fenced and allowed to develop a thick stand of emergent and submergent "marshy" vegetation. These plants utilize much of the nitrogen and phosphorus nutrients from the livestock before they get to the stock pond and cause algae problems. It may not be much more costly to pipe clean pond water to a stock tank below the dam.

2. Fencing—Complete or partial fencing of area on which embankment ponds

are built is usually recommended if livestock are grazed or fed in adjacent fields. Fencing provides the protection needed to develop and maintain good plant cover on the dams, the earth spillway, and other areas. It also provides clean water for stock use and eliminates damage or pollution by livestock. Fencing allows establishment of an environment beneficial to wildlife. The marshy vegetation needed around ponds for satisfactory wildlife food and cover does not tolerate trampling or grazing. Fencing critical parts of livestock watering ponds, particularly the earthfill and the spillway, is usually advantageous even if complete fencing is impractical.

3. Spillway--No matter how well a dam has been built, it can be destroyed during the first severe storm if the capacity of the spillway is inadequate. The function of the spillway is to pass excess storm runoff around the dam so that water in the pond does not rise high enough to damage the dam by overtopping. The spillway must also convey the water safely to the outlet channel below without damaging the downstream slope of the dam. The success of a pond depends on a properly designed and installed spillway.

4. Trickle Tubes--Trickle tubes protect the vegetation in earth spillway channels against saturation from spring flow or seeps that may continue for several days after a storm. A pipe, called a trickle tube, placed under or through the dam provides this protection. The crest elevation of the entrance should be 12 inches or more below the top of the control section of the earth spillway. The trickle tube should be large enough to discharge flow from springs, snowmelt or seepage. It should also have enough capacity to discharge prolonged surface flow following an intense storm. If both spring flow and prolonged surface flow can be expected,

the trickle tube should be large enough to discharge both.

5. Drain pipe--Some governmental agencies require that provision be made for draining ponds completely or fluctuating the water level to eliminate breeding places for mosquitos. Whether compulsory or not, providing for complete draining is desireable and recommended. It permits good pond management for fish and allows maintenance and repair without cutting the fill or using siphons, pumps, or other devices to remove the water. Install a suitable gate or other control device and extend the drain pipe to the upstream toe of the dam to drain the pond.

6. Water-supply Pipes--If water is to be used at some point below the dam for supplying a stock-water tank, for irrigation, or for other uses, provide a water-supply pipe that runs through the dam. This pipe is in addition to the trickle tube. A water-supply pipe should be rigid and have water tight joints, a strainer at its upper end, and a valve at its outlet end. For a small rate of flow, such that is needed to fill stock-water tanks, use 1½ inch diameter steel pipe. For a larger rate of flow such as that needed for irrigation, use steel or asbestos-cement pipe of larger diameter. Water-supply pipes also should have water tight joints and anti-seep collars.

7. Riprap--In most areas the exposed surfaces of a reservoir can be protected by establishing a good cover of sod-forming grasses. Rock riprap is an effective method of control for ponds in which the water level fluctuates widely or if a high degree of protection is required. Riprap should extend from the top of the dam down the upstream face to a level at least 3 feet below the lowest anticipated water level. The layer of stones should be at least 12 inches thick and must be placed on a level

10 inches thick. This bed keeps the waves from washing out the underlying embankment material that supports the riprap. Also riprap provides places for the attachment and growth of aquatic insects, crayfish and other fish food organisms. Placing riprap on the bottom can also greatly increase aquatic insect and crayfish production.

8. Depth--To insure a permanent water supply, the water must be deep enough to meet the intended use requirements and to off-set seepage and evaporation losses. Deeper ponds are needed where a permanent or year-round water supply is essential or where seepage losses exceed 3 inches per month. A minimum depth of 10 feet is usually required to maintain sport fish populations. To maintain the required depth and capacity of a pond, the inflow must be reasonably free of silt.

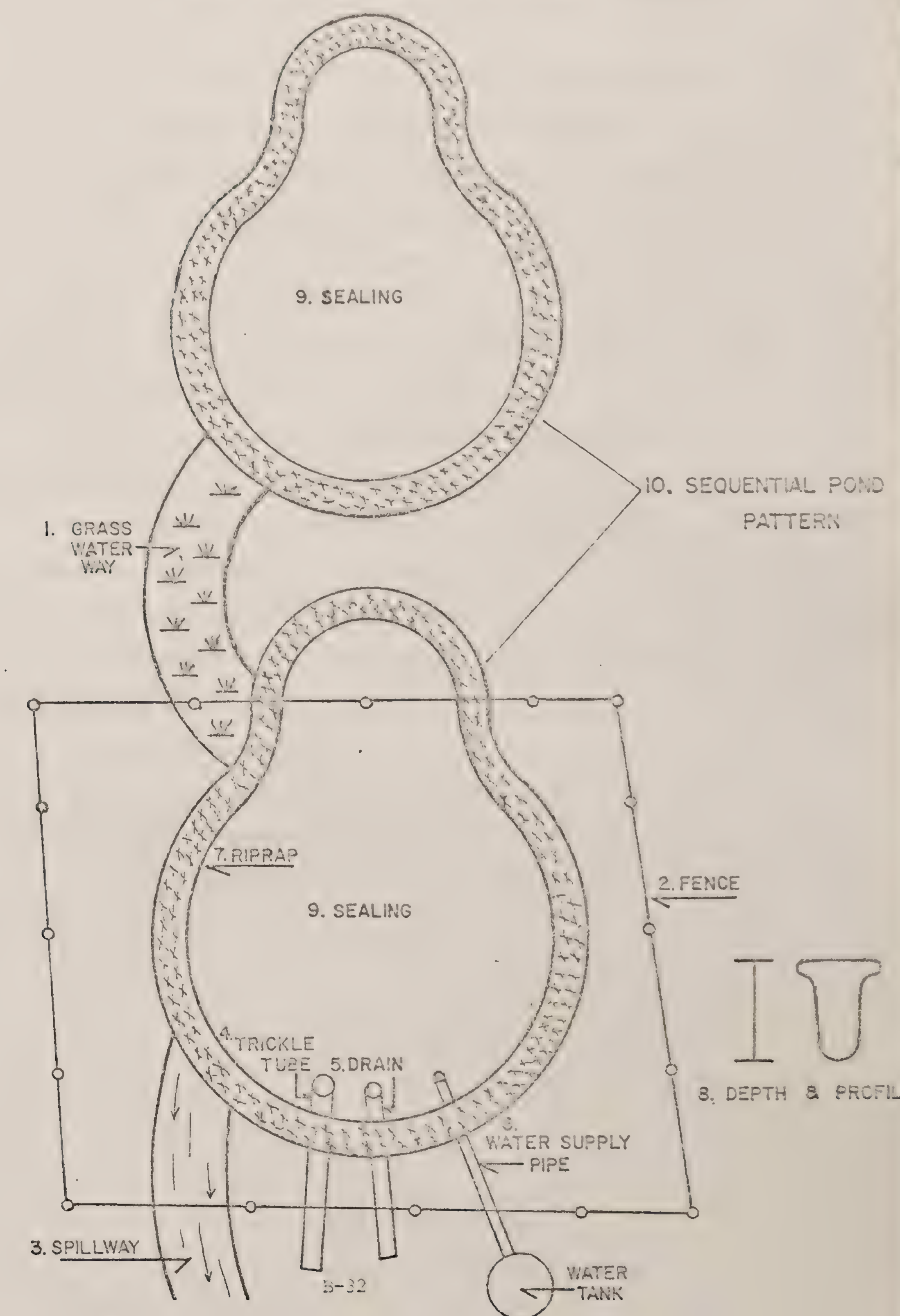
9. Sealing--Excessive seepage in ponds is usually due to a poor site, that is, one where the soils in the impounding area are too permeable to hold water. For these sites, plans for reducing seepage by sealing must be a part of the original design. Bentonite is most often used for sealing purposes. In other places, excessive removal of the soil mantle during construction, usually to provide material for the embankment, exposes highly permeable material such as sand, gravel or rock containing cracks, crevices, or channels. To prevent excessive seepage, you must reduce the permeability to a point at which losses are insignificant or at least tolerable. Seepage losses may be reduced by one of several methods, the choice depends largely on the the proportions of coarse-grained sand, and gravel and of fine-grained clay and silt in the soil.

10. Sequential ponds--There may be many advantages to building small ponds in a sequential pattern. A second dam could catch seepage from the dam above it. Vegetation in the water course connecting the two dams

... will allow nitrate and phosphate thus controlling excessive veg-etation growth in the second pond. The multiple use concept could be achieved by allowing separate design of two different dams. A series of small shallow ponds could overcome limitations where the soil in the impounding area are too permeable to hold water. Small check dams up-stream from the main pond could trap sediment and nutrients before reach-ing the main pond.

Figure 9 incorporates all the mentioned design recommendations necessary for consideration in building new multiple use ponds on the Northern Cheyenne Reservation.

FIGURE 9 POND DESIGN



RECOMMENDATIONS FOR EXISTING PONDS

This section discusses each of the six major ponds on the reservation and presents plans for improving water quality for various uses. The most likely source of money for carrying out pond improvements is the Bureau of Indian Affairs. The tribe may request that the BIA allocate money for such projects through the BIA's "BAND Analysis" program. In this program, which occurs once every year, BIA budget personnel sit down with tribal officials and decide on funding priorities and money allocations 18 months prior to the fiscal year. A tribal request to BIA in this manner could earmark some funds for pond improvements in another year or two. Another possible source of manpower would be the Indian Action Program which is a vocational training project. They have previously assisted in construction of water development projects and required only cost of materials reimbursement. Owners of private ponds could request additional funds for pond improvement that would benefit the public through the tribe, BIA or the county ASCS office.

The Tribe may want to consider negotiating with private landowners for purchase or lease of key pieces of pond shorelines. In the same way, the Tribe may want to negotiate for legal right-of-way to certain private ponds where needed for continued public use.

1. Rednose Reservoir (See Figure 10)

The principal water quality related problem with Rednose Pond is excessive organic waste loading and introduction of nutrients from livestock use of the pond itself and grazing in the Ash Creek watershed. Improvements to the pond are complicated by the fact that the pond is located on allotted and undivided interest land. Some stop-gap measures such as plowing snow off the ice or providing mechanical aeration to the pond throughout the winter may be necessary to prevent fish winterkill such as occurred in April, 1977.

Following is a list of prioritized recommendations for water quality improvements on Rednose Reservoir:

1. Fence livestock off pond with 100 foot buffer strip if permission from landowners can be obtained.
2. Improve off pond stock watering sites.
3. Develop sanitary picnic and parking facilities with landowners' consent.
4. Prevent future winterkill by:
   a) plow snow off ice in winter or install mechanical aerators
   b) dredging shallow pond areas
   c) maintain a high water level before winter freeze-up
5. Improve fishing access by reshaping and stablizing shoreline at several locations.

I. RED NOSE POND
Deafy
Creek
Ash
Well
Reservoir
INDIAN RESERVATION
NORTHERN CHEYENNE INDIAN
CROW
B-35
STRIP
GOVERNMENT DITCH
BM 3435
ROAD CLASSIFICATION
Medium duty
Unimproved dirt
U.S. Route
MONTANA
QUADRANGLE LOCATION
JEANS FORK SE, MONT.
1 MILE

FIGURE: 10

2. Parker Pond (See Figure 11)

Parker Pond's water quality problems appear related to excessive organic waste loading from livestock and aquatic plant growth. Samples of dissolved oxygen taken by the U.S. Fish and Wildlife Service and the [illegible] in June, 1977 indicated that the pond waters were devoid of oxygen below a depth of three meters. The likely cause of this is decomposition of organic matter such as animal wastes and aquatic vegetation. Aquatic plant growth is stimulated by fertile waters containing nitrogen and phosphorous. These nutrients are commonly introduced in elevated amounts from livestock using the pond or surface runoff containing nutrients from animal wastes. The lack of oxygen in Parker Pond may be indirectly remedied by decreasing the amount of organic matter and nutrients entering it. Thus providing off-pond stock use areas may be the best management practice.

While Parker Pond is a private farm pond, it has in the past, been stocked with fish for public use A balance between farm and recreational uses is possible with mutual understanding of the situation and financial support and cooperation from the public or pond users.

Following are a list of prioritized recommendations for Parker Pond:

1. Provide off-pond watering areas for livestock
2. Fence pond perimeter where needed to prevent over-use by livestock.
3. Maintain or enhance marshy areas adjacent to the pond for pike spawning purposes.
4. Maintain high water level prior to winter freeze-up.

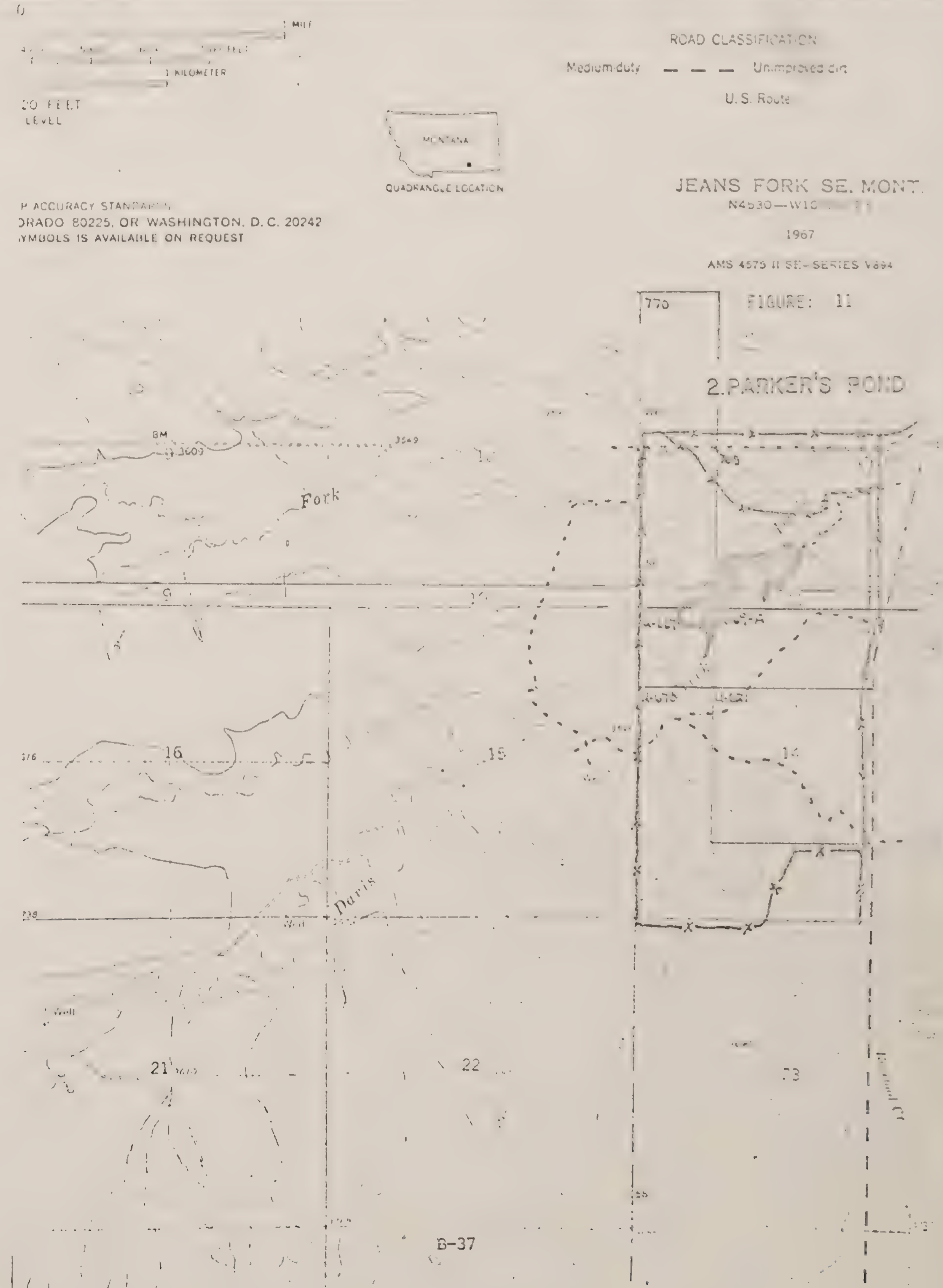


FIGURE: 11

3. LaFever Pond (See Figure 12)

LaFever Pond is in fairly good shape in that Thompson Creek provides an ample supply of good quality water. However, the high nitrate and phosphorous levels found in the pond indicated that care should be taken to prevent eutrophication in the future. While LaFever Pond is a private farm pond, it is open to public use since fish are stocked annually in it. A balance of both needed livestock and recreational uses should be met. Where possible, off-pond watering and wallowing of farm animals would cut down on organic wastes, nutrients, excess algae and weed growth.

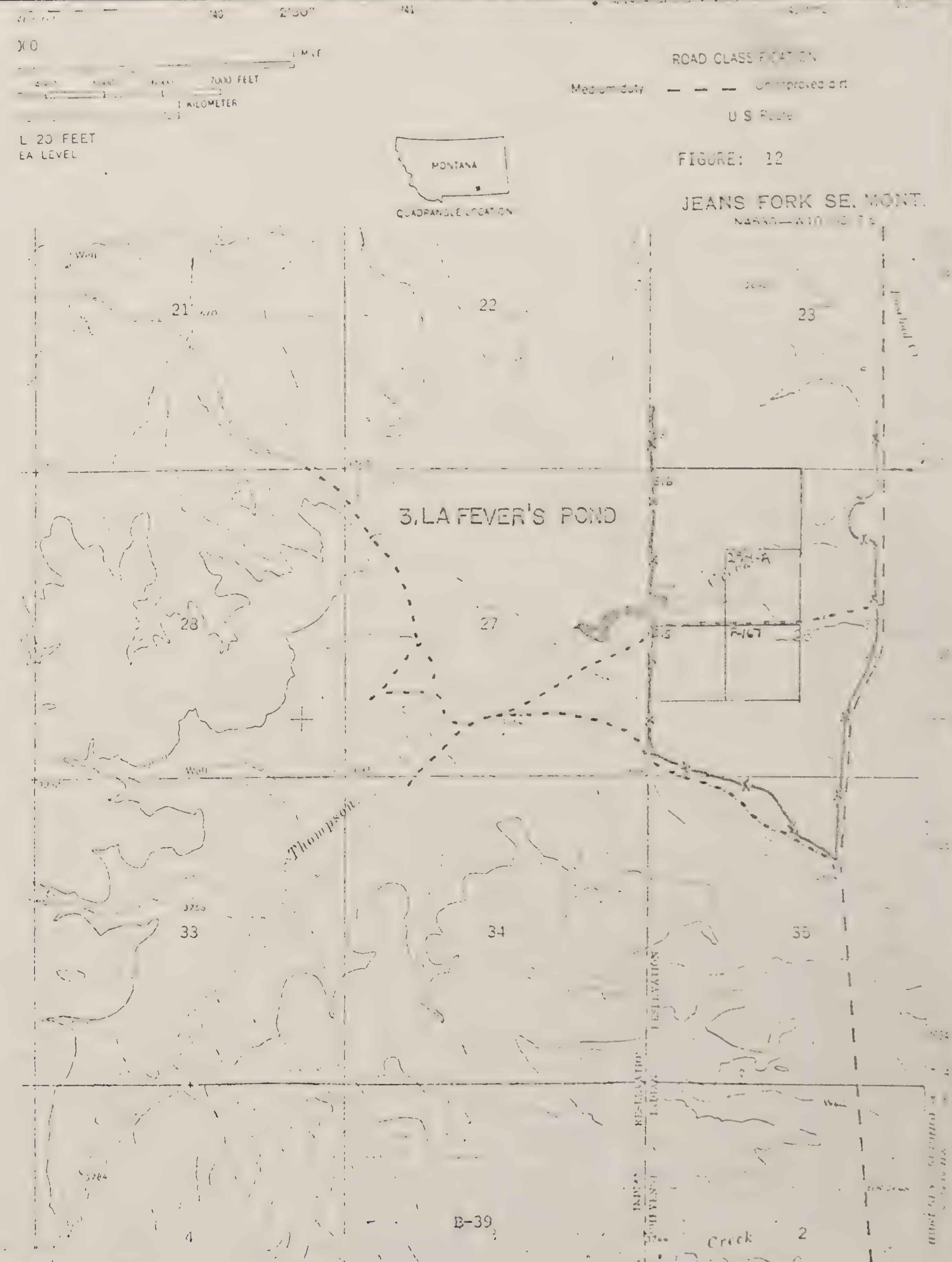
The pond owner has indicated he would like to construct one or two additional ponds below the present one. If stock use and irrigation are then directed to the lower pond, water quality could be improved in the upper pond. The upper or present pond could help insure a more reliable supply of good water for stock and irrigation uses from the downstream ponds. A new access road to the present pond planned for the north side of the stream will prevent conflicts between recreational users and ranch operations.

Following are a list of prioritized recommendations for LaFever Pond:

1. Develop one or two new ponds downstream for livestock and irrigation uses. Maintain present pond for fish and wildlife and reliable water supply.

2. Construct new access road to pond along north side of fields.

3. Maintain and enhance marshy areas and buffer strip of vegetation around the pond.



4. Lost Leg Lake (See Figure 13)

The main water quality related problems associated with Lost Leg Lake is the excessive seepage loss compared to the limited water supply, its shallow design and heavy use as a stock watering area. While lining of the pond would be expensive, some benefits could be realized by fencing the pond and a 100 foot buffer strip. Off-pond stock watering would have to be developed. A stock tank located just below the pond or auxillary pond with a vegetative waterway may be two practical solutions.

Following is a list of prioritized recommendations for this pond:

1. Fence off pond and buffer strip
2. Provide off-pond stock water
3. Seal pond bed
4. Plow snow off ice or install mechanical aerators in winter
5. Provide sanitary facilities
6. Repair picnic and camping area

FIGURE: 13

FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER 25, COLORADO OR WASHINGTON 25, D.C.

QUADRANGLE LOCATION

FISHER BUTTE, MONT

1958

5. Greenleaf Pond (See Figure 14)

The main water quality related problem associated with Greenleaf Pond is the heavy recreational use it receives by reservation residents in summer. Trampling at banks, worm digging and trash littering are several outstanding problems. The Greenleaf site could be developed with one to three additional ponds below the present one. Provision of public facilities and spreading out of the use would benefit the pond and people using it.

Following is a list of prioritized recommendations for this pond:

1. Stop worm digging along bank to prevent erosion and replant disturbed areas
2. Provide trash barrels and trash pick up
3. Build lower ponds
4. Install toilets
5. Improve picnic and parking area

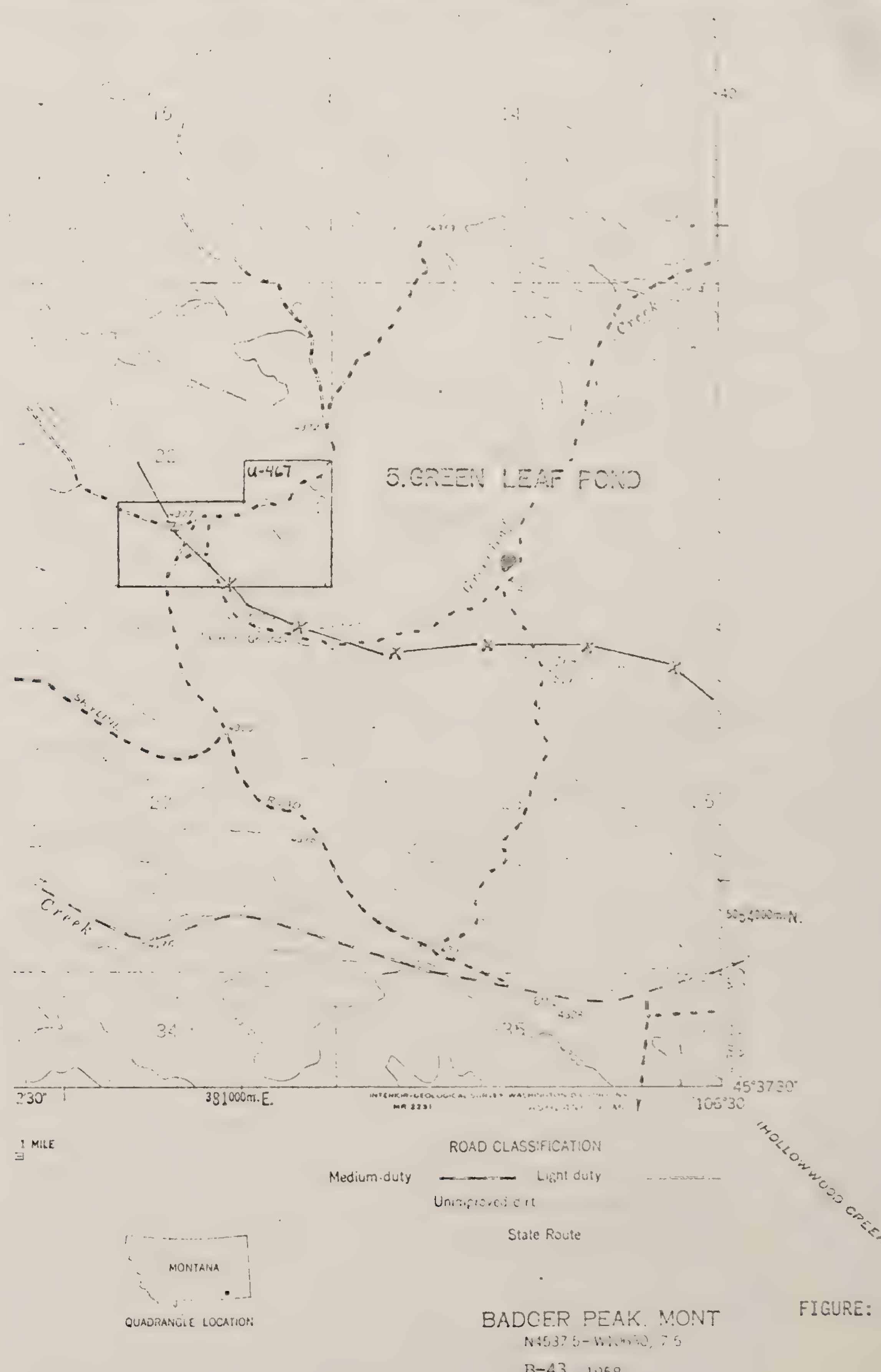


FIGURE: 14

6. Crazy Head Spring Ponds (See Figure 15)

The main water quality related problems associated with Crazy Head Spring Ponds is the use of the ponds for stock watering purposes and heavy recreational use in the summer. The pond area is fenced, but gates are not kept closed particularly on the fourth or lowest pond. Additional cattle guards should be installed. If the lowest pond is to be used primarily for recreation, additional stock watering provisions are needed below the fourth pond. Public facilities and trash pick up have recently been improved and should be maintained.

Following is a list of prioritized recommendations for this pond:

1. Designate last pond for stock use only or provide other water by piping to stock tank or pond below
2. Fence springs and provide other stock water source
3. Install and use gates or cattle guards
4. Trash pick up
5. Improve parking and picnic areas
6. Rebuild toilets and camping facilities

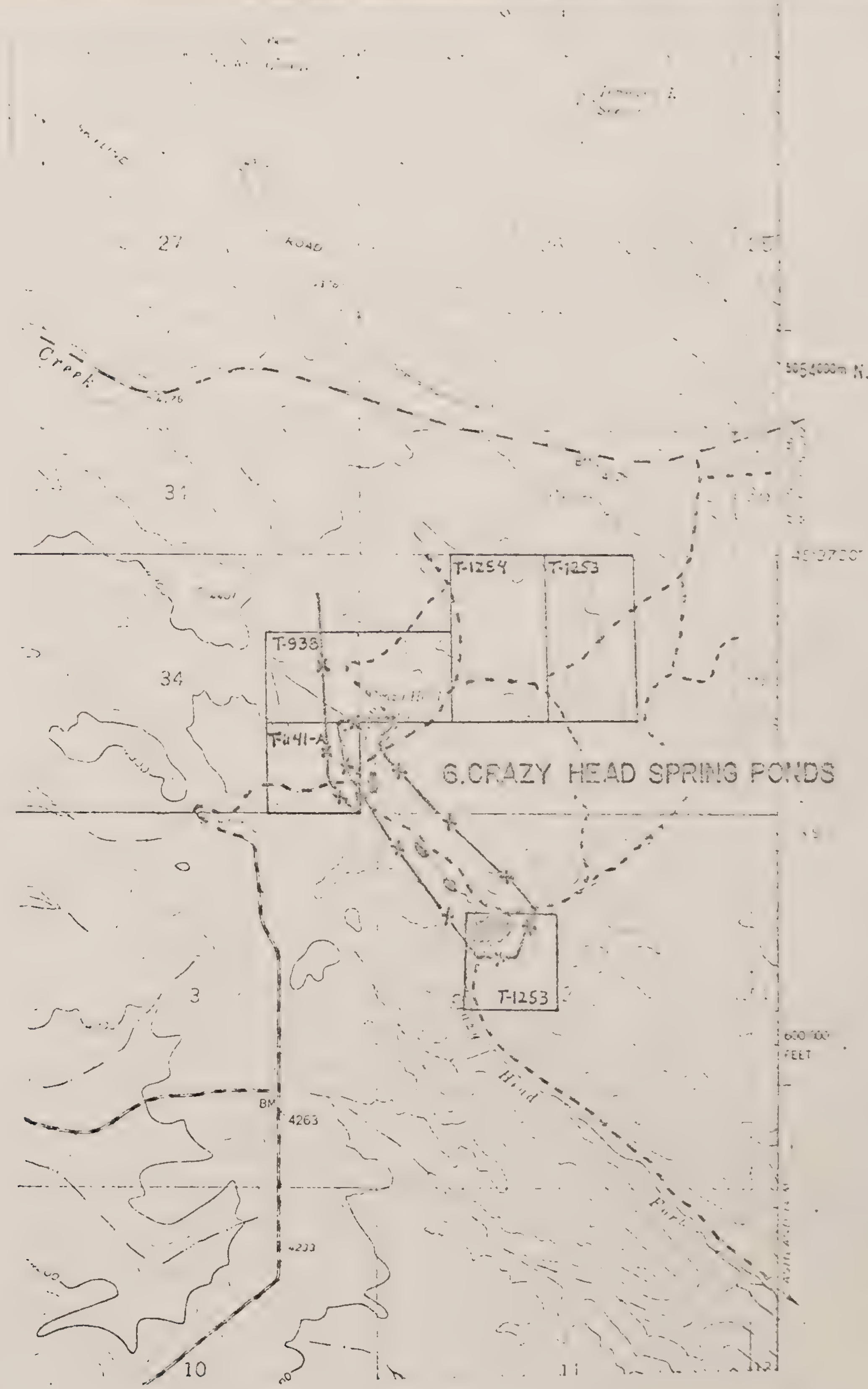


FIGURE: 15

FISHER BUTTE QUADRANGLE
MONTANA-ROSEBUD CO
7.5 MINUTE SERIES (TOPOGRAPHIC)
(GARFIELD PEAK)

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SOIL SUITABILITY FOR POTENTIAL MINED LAND RECLAMATION IN RELATION TO WATER QUALITY

Why Soils Information is Important

One of the three major sub-parts of the 208 non-point source water quality studies on the Northern Cheyenne Reservation deals with the suitability of selected soil types for potential mined land reclamation and the implications this holds for water quality. Assessing the potential impacts to water quality from surface coal mining was a main reason behind designating this region as a "208" study area. The Northern Cheyenne Tribe has not yet decided whether to mine any of their coal. Uncertainties over potential environmental impacts is regarded as an important factor. Major water quality questions surround the ultimate success or failure of mined land reclration, such as: erosion, sedimentation, and salinity alteration of surface and ground waters. Several studies [1,2,3] either suggest or have documented the occurrance of surface and ground water pollution from surface mined land.

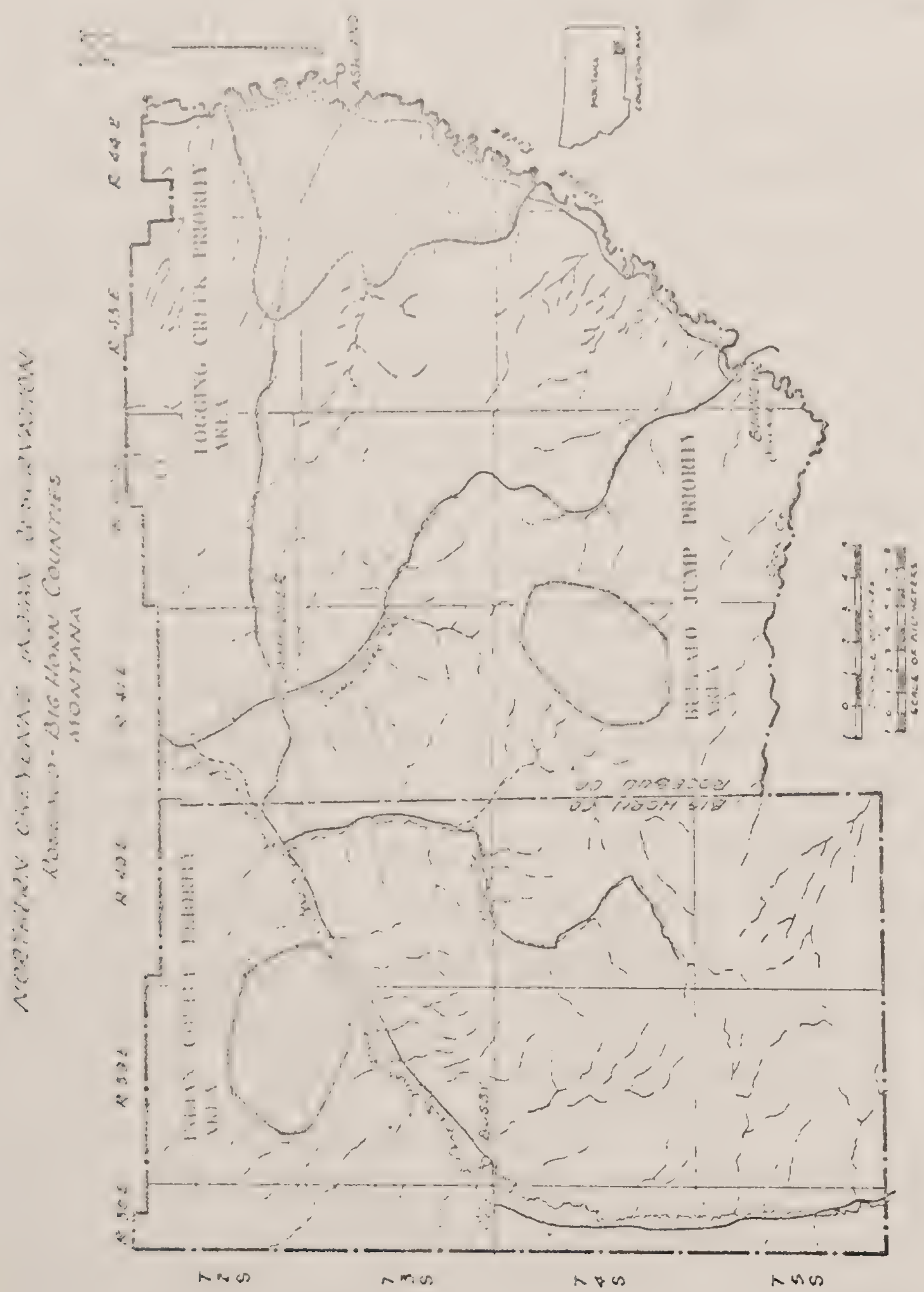
Since many of the potential water quality impacts are related to the success of revegetation of mine spoils, the NCRP 208 program conducted a soil suitability sampling program. Pre-mining soils data is used by governmental agencies and mining companies to assess reclamation success and plan revegetation programs. Such information can be used by the Northern Cheyenne Tribe to assist in decisions on coal mining and water quality maintenance, and in developing best mining and mine spoils management practices for reservation lands.

The Soil Sampling Program

Fifteen different soil types from three different areas on the reser-

vation were sampled. The three areas, Logging Creek, Buffalo Jump and Indian Coulee are shown in Figure C-1. These areas were chosen because they were already under intensive study as part of the Northern Cheyenne Research Project (NCRP) surface and ground water impact investigation. The areas all have mineable coal and well represent the range of soil and site conditions found on the reservation. Five of the most widespread soil types in each area were sampled. Soil types, either a single soil series or a soil complex, were located from the mapping units on the soil survey field charts. A professional soil survey on the reservation was performed in summer, 1975.[4] In each soil type, twenty holes were hand augered to a depth of four feet. Holes were spaced at medium density over the soil type, 300 to 1400 feet apart. Composite samples of each major soil horizon were blended. Soil horizon zones were determined from USDA soil interpretation sheets and in-field observations. Soil horizons in each auger hole were logged and described as to color, texture, depth and special characteristics. A total of 48 separate composite samples were gathered. Soil samples were air dried and split into two parts, one for chemical analysis and the other kept for later use.

In a number of the soil types, particularly the soil complexes, widely varying field conditions were found, even within the same soil horizon zone. The 1975 soil survey was done on a "dry land" level of intensity and is therefore generalized. Attempts were made to avoid sampling too close to soil type boundaries. Sampling locations within each soil type were chosen with best judgement so as to incorporate most site conditions found within the type. Modifications were made to stay on tribal land as much as possible. Samples were gathered during September, October and November, 1976. It should be emphasized that this was a reconnaissance level sampling program to determine



NCRP Priority Area Study Sites

only relative suitability of selected soils and areas on the reservation.

Soil Parameters Tested

Approximately one kilogram (2.2 pounds) of each soil sample was mailed to Montana Testing Laboratories, Inc., Great Falls, Montana, for laboratory analysis. The parameters analyzed were based on the same ones that the Montana Department of State Lands uses as a guide for rating soil material for use as a final cover for mined land. The following parameters were tested:

pH

Saturation percentage

Electrical Conductivity

Mechanical Analysis

Calcium (Ca), Magnesium (Mg), Sodium (Na)

Sodium Adsorption Ration (SAR)

Boron

Organic Matter Percentage

The above parameters are all important in determing the particular productivity characteristics of soils. The pH of most arid region mineral soils in the west is normally slightly to moderately alkaline, meaning a pH value of 7 to 9. The availability of several essential elements in plant growth is decreased as the pH is raised from 5.0 to 8.0. The solubility of certain elements that are toxic to plant growth is also affected by pH. At very high pH values, for example the bicarbonate ion is sometimes present in sufficient amounts to interfere with the normal uptake of other ions and thus is detrimental to good plant growth.[5]

The saturation percentage is the moisture content at a water saturated

soil paste. Soil - water extracts are taken from this paste for each soil sample to conduct the electrical conductivity, salinity and boron tests.[6]

Electrical conductivity is commonly used for indicating the total concentration of ionized chemical constituents of solutions. It is closely related to the sum of the cations or anions as determined through chemical testing and correlates closely with total dissolved solids measurements. It is a quick and relatively accurate way of measuring the degree of salinity in the soil. Saline soils are defined as having an electrical conductivity greater than 4 millimhos per centimeter.[5]

Mechanical analysis is a method of classifying soil according to its texture or proportion of various size soil particles. Soil texture is a property that cannot be altered and so is considered a basic property of a soil. Soil texture is normally classified according to the percent of clay, silt, sand and gravel contained in the soil sample. These various size groups are determined by the relative velocity with which they settle out of a water suspension. The mechanical analyses allows each soil sample to be given a soil textural class name, such as clay, clay loam or sandy clay loam. A soil to be designated a clay must carry at least 35 to 40 percent of the clay separate. In such a soil the clay separate is dominate and the soil is highly plastic, becoming sticky when too wet, and hard and cloddy when dry unless properly worked.

The concentrations of the chemicals calcium (Ca), magnesium (Mg), and sodium (Na) are needed to determine the sodium adsorption ratio (SAR). The SAR is an indication of the sodium hazard of a soil to plant growth. It is defined as being:

$$\frac{Na^{+}}{\sqrt{Ca^{2+} + Mg^{2+}/2}}$$, with all concentrations expressed in milli-

equivalents per liter. In soils with SARs greater than 10, there are enough adsorped sodium ions to adversely affect many plants. Sodium ions also disperse the mineral colloids of the soil, causing a tight, impervious soil structure.

Boron is an important micronutrient that can be present in too great amounts and be toxic to plants or can be deficient for adequate plant growth. It is often naturally deficient in many of the arid western soils. It's normal range is from 50 to 150 parts per million (ppm). Plant growth may be retarded at levels less than 0.5 ppm.

The percentage of organic matter in most natural soils varies from 15 to less than one percent. Organic matter plays an important role in the natural soil by keeping it loose and open and is an essential source of several nutrient elements. It is derived from the decay of vegetation and animal matter and is usually most concentrated at the surface of the soil.

The laboratory results, along with general soil series interpretations, were used to draw preliminary conclusions about the suitability of each soil mapping unit and horizon for stockpiling as final cover material if mining were to occur.

Red Flag Levels

The Montana guide for rating soil material as revised 6-30-77 gives the following values as "red flag" or warning levels for the various parameters

Soil Characteristics			Red Flag Level
pH		greater than	8.8-9.0
Electrical Conductivity		"	4-6 mhos
SAR		"	12
Mechanical Analysis	clay	"	40 percent
Boron			8 ppm

If reported soil characteristics exceed these values, there is cause to be concerned that normal reclamation procedures may be insufficient or that reclamation may not be successful with this soil type as the final cover material. Values of soil characteristics exceeding those given above have been shown to inhibit normal germination and growth of many plants. Comparison of red flag levels with testing results of reservation soils gives an understanding of potential reclamation and water quality problems [illegible].

Laboratory Results and Analysis

All soil samples were initially passed through a number nine mesh screen for mechanical analysis and a number twenty mesh screen for chemical analysis. Results will be presented for each sampling area, Logging Creek, Buffalo Jump and Indian Coulee, in two tables, one of chemical properties and one of mechanical analysis, boron and organic matter. A description of each soil mapping unit and its suitability for use as a final cover material accompanies the tables.

Table 1 Chemical Properties of Soils taken from the Logging Creek Area.

Lab No.	NCRP No.	Depth inches	pH Paste	Sat'n. %	Saturation Extract: Elect. Cond. mmhos/cm	Cations: Ca (meq/liter)	Mg	Na	S.A.R.
12E, Birney Channery Loam, 15-25% slopes									
4145	1	3	7.8	41.7	0.5	5.0	1.5	0.02	0.01
4146	2	12	8.2	39.2	0.5	2.8	1.2	3.2	2.30
4147	3	40	8.3	36.5	8.5	18.3	39.7	74.5	13.80
591E, Kobar-Yawdim-Cabbart, 8-25% slopes									
4148	4	3	8.0	41.1	3.0	16.9	6.9	24.1	[illegible]
4149	5	15	8.0	44.3	6.0	19.1	20.4	54.3	[illegible]
4150	6	40	8.3	41.6	10.0	18.5	29.9	105.8	[illegible]
592D, Kobar Silty Clay Loam, Dissected, 2-15% slopes									
4151	7	3	8.0	46.1	2.5	13.5	6.9	15.8	4.90
4152	8	15	8.1	45.6	5.0	20.3	20.9	39.8	8.80
4153	9	40	8.5	38.3	12.5	18.3	49.0	111.8	19.30
498F, Cabbart-Yawdim-Yamac, 25-70% slopes									
4154	10	3	7.9	39.6	3.7	23.5	10.9	23.1	5.60
4155	11	15	7.9	37.7	7.2	20.3	28.5	64.4	13.00
4156	12	40	7.4	102.0	11.5	20.7	47.6	108.7	18.60
37C, Lonna Silt Loam, 2-8% slopes									
4157	13	3	8.0	44.8	0.8	13.4	1.6	4.2	[illegible]
4158	14	15	8.2	40.6	4.6	17.3	17.1	37.3	[illegible]
4159	15	40	8.6	38.8	10.5	18.3	41.2	93.2	1.10

a) ( ) Indicates that the "red flag" levels have been equalled or exceeded.

Table [illegible] with Boron and Organic
[illegible] Creek Area

[illegible]	[illegible]	[illegible]	[illegible] %	[illegible] %	[illegible] %	Texture	Boron ppm	Organic Matter %
[illegible]								
[illegible]	1	[illegible]	57.2	[illegible]	16.2	SCL	0.54	1.78
[illegible]	2	12	45.4	22.6	32.0	L	0.66	0.34
[illegible]	3	40	[illegible]	[illegible]	21.8	SCL	1.26	0.15
[illegible]								
[illegible]	[illegible]	2	[illegible]	[illegible]	25.4	CL	0.55	0.92
[illegible]	[illegible]	[illegible]	44.2	[illegible]	15.8	C	0.60	1.01
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	CL	0.65	0.15
[illegible]								
[illegible]	7	3	[illegible]	[illegible]	[illegible]	CL	0.62	2.16
[illegible]	[illegible]	15	[illegible]	[illegible]	[illegible]	CL	0.63	0.63
[illegible]	[illegible]	45	[illegible]	[illegible]	23.3	CL	0.78	0.15
[illegible]								
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21.8	CL	0.50	0.44
[illegible]	[illegible]	18	36.4	[illegible]	23.0	C	0.72	0.82
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	C	0.99	1.97
[illegible]								
[illegible]	13	3	[illegible]	[illegible]	[illegible]	[illegible]	0.68	2.06
[illegible]	[illegible]	15	[illegible]	[illegible]	23.4	CL	0.72	0.44
[illegible]	[illegible]	[illegible]	[illegible]	34.6	21.8	CL	1.01	0.15

[illegible]

[illegible] "red flag" levels have been equaled or exceeded

Birney Channery Loam 15 - 25 percent slope (12 E) Tables 1 and 2

This soil is a deep loamy soil over burned shale and sandstone with 40 to 60 percent coarse fragments. Bedrock at 40 inches will eliminate any possibility of soil below 40 inches for use other than to place this material to its original depth or lower. The coarse fragments will make this soil difficult to justify for use on the surface.

Chemically, soluble salts (table 1) below 12 inches exceed values that may restrict germination and establishment of seedlings. In addition, between 12 - 40 inches depth, the SAR values exceed 12 and may cause crusting of soil that may prevent seedling emergency.

This soil with coarse fragments on the surface 12 inches and soluble salts below 12 inches make the soil very limited in its uses. This soil should not be permitted for stockpiling or revegetation purposes.

Kobar - Yawdim - Cabbart (591 E) Tables 1 and 2

These soils in complex with one another make up the soil series. Kobar soil makes up about 40 percent of the mapping unit, Yawdim about 20 percent, and Cabbart about 20 percent. The other 20 percent is composed of small areas of Yamac and Lonna soils and rock outcrops.

Chemically, Kobar contains soluble salts below 15 inches exceeding 6 mmhos/cm with very high SAR values (21.50). The texture is clay loam and with high SAR value, the soil may disperse and develop crusting. The SAR value between 3 and 15 inches is 12. Kobar from the surface 6 inches of this complex could be used for stockpiling for revegetation purposes.

The Yawdim in the complex represents a silty clay texture with less than 20 inches to shale and normally found on knolls. This soil is known to have soluble salts below the surface. Cabbart in the complex represents

a more loamy texture over a soft shale and siltstone with less than 20 inches depth. Both Yawdim and Cabbart are soils with limited depth and contain soluble salts. Both of these soils are limited in their use also.

For revegetation purposes, both of these soils should not be permitted for stockpiling below 6 inches.

Kobar Silty Clay Loam (592 D) Tables 1 and 2

Kobar silty clay loam is normally deep and located on fans and footslopes. It contains moderately low soluble salts from 0 - 15 inches. Soils of this nature could be used for stockpiling purposes from 0 - 15 inches. Below 15 inches the SAR values exceeded 12 and could develop a physical problem that may affect infiltration and permeability. Soil material below 15 inches appears limited due to high SAR soluble salts. Therefore, Kobar silty clay loam (592 D) may have 15 inches of topsoil that could be used for final cover material.

Cabbart - Yawdim - Yamac (498 F) Tables 1 and 2

The Cabbart and Yawdim was described previously. The Yamac is similar to Kobar or Lonna soils. 'It is a deep loamy soil developed on fans or footslopes. This complex is found on very steep slopes. While the Yamac portion of this complex is a favorable soil for plant growth, it is estimated to comprise only 25 percent of the complex. The thinner and more saline Cabbart and Yawdim soils dominate the complex resulting in poor quality soil [illegible].

The chemical characteristics of this soil have poor quality for reclamation purposes. The SAR values exceed 12 below 3 inches depth and limits the stockpiling potential of the surface soil to 3 inches or possibly six inches. It is recommended that the mapping unit be used for stockpiling purposes only to a depth of six inches.

Lonna Silt Loam (37 C) Tables 1 and 2

Lonna silt loam is a deep soil located on fans, terraces, and footslopes. It is generally a productive soil. The chemical characteristics of this soil appear to be low in soluble salts with favorable textures between zero and fifteen inches. Soluble salts were found below 15 inches and may restrict production. Lonna silt loam appears to have 15 inches of acceptable soil for stockpiling purposes.

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Shambo - Doney Loams (433 E) Tables 3 and 4

Sambo is described as a deep loamy soil with greater than forty inches to sandstone shale. It is generally described as a productive soil and has other land use capability. Chemically, soluble salts and SAR are very low and should not restrict plant growth and development. For stockpiling purposes, this soil could be used to 40 inches depth or more.

Doney is described as moderately deep, with bedrock at 30 inches. It has the same qualifications as Shambo for stockpiling purposes except for more limited depth.

Chama Silt Loam (20 C) Tables 3 and 4

Chama is described as a deep silty soil. It is underlain with soft sandstone and shale below 40 inches. It is a productive soil and has several land use capabilities.

Chama has low soluble salts and SAR. It should not restrict plant growth and development. Texture is favorable for water holding capacity and should be capable of providing an excellent moisture storage capacity.

Chama silt loam could be used for revegetation purposes and soil could be used to a depth of 40 inches or to bedrock.

Table 3 Chemical Properties of Soils taken from the Buffalo Jump Area.

Lab No.	NCRP No.	Depth inches	pH Paste	Sat'n. %	Elect. Cond. mmhos/cm	Saturation Extract Cations Ca	Mg	Na	SAR
						- - meq/liter - -			
433E, Shambo-Doney Loams, 8-35% slopes									
4160	16	3	7.8	47.0	0.7	5.0	2.0	2.0	1.10
4161	17	15	8.2	44.1	0.4	3.2	1.7	0.8	0.50
4162	18	40	8.2	44.8	3.7	18.7	30.4	10.8	2.20
20C, Chama, Silt Loam, 2-8% slopes									
4163	19	3	7.4	40.1	0.6	4.2	1.8	0.02	0.01
4164	20	18	8.0	44.7	0.4	3.2	0.3	0.5	0.40
4165	21	48	8.4	39.3	2.2	5.4	11.1	13.3	4.60
144C, Bitton-Twin Creek, 2-8% slopes									
4166	22	3	7.8	44.3	0.6	4.4	1.5	0.7	0.40
4167	23	15	8.1	42.4	0.7	2.8	1.2	5.0	3.50
4168	24	30	7.9	38.9	0.4	2.2	1.5	0.7	0.50
4169	25	48	8.4	40.5	0.5	1.4	2.2	3.0	2.20
534D, Shambo-Cabba Loams, 8-15% slopes									
4170	26	3	7.7	47.5	0.6	5.0	2.0	0.02	0.01
4171	27	15	8.0	43.7	0.7	4.6	2.5	0.5	0.30
4172	28	30	8.2	45.6	1.7	8.4	11.9	4.0	1.30
4173	29	48	8.4	46.2	2.5	8.0	20.4	11.6	3.10
831D, Castner-Shambo, 2-15% slopes									
4174	30	3	8.0	44.7	0.6	6.4	1.5	0.02	0.01
4175	31	15	8.0	45.8	1.0	8.0	3.9	2.5	1.00
4176	32	15-30	8.4	41.3	0.4	2.8	2.0	0.5	0.30
4177	33	48	8.6	33.1	1.7	3.0	11.4	9.5	3.50

a) ( ) indicates that the "red flag" levels have been equaled or exceeded

Table 4 Results of Mechanical Analysis (Hydraulic Method) with Boron and Organic Matter on Soils taken from the Buffalo Jump Area.

Lab No.	NCRP No.	Depth inches	Mechanical Analysis Sand %	Clay %	Silt %	Texture a)	Boron ppm	Organic Matter %
433E, Shambo-Doney Loams, 8-35% slopes								
4160	16	3	37.2	37.6	25.2	CL	0.69	2.93
4161	17	15	36.0	38.8	25.2	CL	0.65	0.53
4162	18	40	31.8	38.8	29.4	CL	0.82	0.15
20C, Chama, Silt Loam, 2-8% slopes								
4163	19	3	35.4	30.8	33.8	CL	0.77	3.49
4164	20	18	24.8	37.8	37.4	CL	0.55	0.72
4165	21	48	35.0	34.8	30.2	CL	0.26	0.15
144C, Bitton-Twin Creek, 2-8% slopes								
4166	22	3	33.6	29.8	36.6	CL	0.25	2.73
4167	23	15	31.6	33.8	34.6	CL	0.24	0.92
4168	24	30	26.6	29.8	43.6	CL	0.24	0.15
4169	25	48	35.8	27.8	36.4	CL	0.44	0.15
534D, Shambo-Cabba Loams, 8-15% slopes								
4170	26	3	33.6	32.2	34.2	CL	0.34	3.49
4171	27	15	28.6	37.2	34.2	CL	0.34	1.39
4172	28	30	22.6	37.8	39.6	CL	0.44	0.72
4173	29	48	27.6	38.2	34.2	CL	0.65	0.53
831D, Castner-Shambo, 2-15% slopes								
4174	30	3	39.6	27.2	33.2	CL	0.50	2.93
4175	31	15	30.6	35.6	33.8	CL	0.57	1.11
4176	32	15-30	25.8	36.6	37.6	CL	0.57	0.15
4177	33	48	42.6	23.6	33.8	L	0.39	0.15

a) C - Clay
S - Sandy
L - Loam
Si - Silty

Bitton - Twin Creek Loam ([illegible]) Tables 3 and 4

Bitton is a deep loam soil over burned shale and sandstone. It contains 40 to 60 percent coarse fragments in the upper 40 inches. There usually is bedrock below forty inches. Chemically, the soil contains very low soluble salt and SAR values. It has a favorable texture for moisture storage. The upper 6 inches of soil is recommended for final cover material for revegetation purposes.

Twin Creek is also a deep reddish loam. It contains coarse fragments also, but is considered a more favorable soil for revegetation purpose. The upper 12 inches of the soil is recommended for revegetation purposes.

Cabba - Shambo Loam ([illegible]) Tables 3 and 4

Shambo was described previously. Cabba is similar to Cabbart but occurs in a higher rainfall zone. It is 6 to 20 inches to bedrock of soft sandstone or siltstone. Chemical characteristics of the soil do not indicate high soluble salts or SAR. It should not restrict plant growth and development. Cabba can be recommended for topsoil material to a depth of 20 inches or to bedrock whichever comes first.

Castner - Shambo - Chaney Loam (831 D) Tables 3 and 4

Castner is described as a shallow stony soil. It contains coarse fragments and is not suitable for topsoil material. Chemically, Castner contains very low soluble salts and SAR. It is recommended that this mapping unit, because of the physical problem associated with the soil, should not be permitted for use for revegetation purposes.

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Yamac - Cabbart (493 E) Tables 5 and 6

Yamac was described earlier and its characteristics will be similar. It was described as a deep loamy soil and located on fans and footslopes.

Cabbart was described as a thin, saline soil that was relatively poor for revegetation purposes. The chemical characteristics of the complex indicate that soluble salts exceed 6 mmhos/cm between 15 to 40 inches and this zone is not recommended for stockpiling purposes. It is recommended that the mapping unit of Yamac - Cabbart be used for revegetation purposes to a depth of 15 inches only.

Cabba - Wayden Shale Outcrop (171 F) Tables 5 and 6

Wayden was described as similar to Yawdim. It is a silty clay loam texture with bedrock within 20 inches. It may contain soluble salts. This particular mapping unit is located on very steep slopes (25 to 70 percent) and may be difficult to use for stockpiling for revegetation purposes. This particular mapping unit of Cabba - Wayden shale outcrop does not appear to have any soil that could be used for topsoil stockpiling purposes, except for the Cabba series that was described earlier. Because these soils occur in complex or together in the mapping unit, it may be difficult to locate an area of Cabba large enough within the mapping unit to separately stockpile for revegetation purposes.

It is recommended that since the mapping unit contains shale outcrop and possible soluble salts in the Wayden series, this mapping unit should not be used for stockpiling purposes.

Havre Loam (311) Tables 5 and 6

Havre loam is normally located on bottom land associated with alluvium material. If it does not contain soluble salts, it is generally a very productive soil. This mapping unit, however, is described also as occasionally flooded and could remain wet for prolonged periods.

Chemically, the soil contains moderately low soluble salts which could affect yield to a certain extent. However, it should not affect germination

Table 5 Chemical Properties of Soils taken from the Indian Coulee Area.

Lab No.	NCRP No.	Depth inches	pH Paste	Sat'n. %	Elect. Cond. mmhos/cm	Saturation Extract Cations Ca	Mg	Na	SAR
						– – meq/liter – –			
493F, Yamac-Cabbart Loams, 15-25% slopes									
4178	34	3	8.1	40.3	0.8 a)	6.4	2.7	0.7	0.30
4179	35	15	8.1	34.2	4.0	19.9	27.1	18.4	3.80
4180	36	40	8.6	31.7	7.5	19.5	61.1	41.5	6.50
171F, Cabba-Wayden-Shale Outcrop, 25-70% slopes									
4181	37	3	8.1	39.3	1.8	16.9	6.2	1.2	0.40
4182	38	15	8.1	32.7	3.0	22.3	18.7	5.5	1.20
4183	39	40	8.3	33.0	5.0	19.9	50.0	21.1	3.60
311, Havre Loam, occasionally flooded									
4184	40	3	8.0	34.5	4.7	24.7	15.6	14.6	3.30
4185	41	15	8.1	34.5	4.8	21.5	29.9	26.1	5.10
4186	42	40	8.2	29.2	4.3	20.7	29.4	16.8	3.40
496E, Yamac-Birney-Cabbart, 15-25% slopes									
4187	43	3	8.1	35.6	0.9	7.4	2.9	1.2	0.50
4188	44	10	8.3	31.2	0.6	4.2	2.2	0.5	0.30
4189	45	40	8.2	38.5	4.0	19.9	37.8	11.6	2.20
49C, Yamac Loam									
4190	46	3	8.1	37.0	0.9	6.8	3.2	0.3	0.10
4191	47	18	8.2	37.8	4.1	20.3	32.7	16.1	3.10
4192	48	40	8.4	33.8	7.6	22.3	64.5	37.1	5.60

a) Indicates that the "red flag" levels have been equaled or exceeded

Table 6 Results of Mechanical Analysis (Hydrometer Method) with Boron and Organic Matter on soils taken from the Indian Coulee Area.

Lab No.	NCRP No.	Depth inches	Mechanical Analysis Sand %	Clay %	Silt %	Texture a)	Boron ppm	Organic Matter %
493E, Yamac-Cabbart Loams, 15-25% slopes								
4178	34	3	29.6	27.6	42.8	CL	0.68	1.97
4179	35	15	34.6	32.6	32.8	CL	1.50	0.25
4180	36	40	24.6	9.6	65.8	SiL	0.88	0.15
171F, Cabba-Wayden-Shale Outcrop, 25-70% slopes								
4181	37	3	36.6	26.6	36.8	L	0.60	2.64
4182	38	15	25.6	29.6	44.8	CL	0.74	0.92
4183	39	40	26.4	32.6	41.0	CL	0.94	0.15
311, Havre Loam, occasionally flooded								
4184	40	3	37.0	21.6	41.1	L	0.79	1.37
4185	41	15	42.6	19.6	37.8	L	0.88	1.30
4186	42	40	44.6	19.6	35.8	L	0.98	0.44
496E, Yamac-Birney-Cabbart, 15-25% slopes								
4187	43	3	52.6	20.2	27.2	SL	0.55	1.78
4188	44	10	43.0	25.2	31.8	L	0.54	0.44
4189	45	40	50.6	21.1	28.2	L	0.67	0.15
49C, Yamac Loam								
4190	46	3	33.6	27.2	39.2	L	0.58	2.06
4191	47	18	34.6	32.6	32.8	CL	1.36	0.25
4192	48	40	35.6	23.2	41.2	L	1.21	0.15

a) S - Sandy
C - Clay
L - Loam
Si - Silty

and establishment and could be used for stockpiling purposes. It has a desirable texture and should maintain favorable production. This mapping unit is recommended for stockpiling purposes to a depth of 40 inches.

Yamac - Birney - Cabbart (496 E) Tables 5 and 6

Yamac series was described earlier as a deep loamy soil to 40 inches located near footslopes or fans. Yamac generally is a highly productive soil if soluble salts are absent or low. The mapping unit of Yamac - Birney - Cabbart includes soils that are shallow, with 20 inches to soft siltstone or shale (Cabbart) or with coarse fragments (Birney) over burnt shale.

The soluble salts of the mapping unit are low and because of the depth of the soil, it appears that the soil was taken from an area of Yamac series dominating within the mapping unit. It is recommended that the mapping unit be used for topsoil material to 12 inches except when the coarse fragments are present.

Yamac Loam (49C) Tables 5 and 6

Yamac loam was described earlier as deep loamy soil located on fans and near footslopes. Yamac loam appears to be a productive soil if soluble salts are low. It has favorable texture for water holding capacity and in- [illegible] salts are moderately high below 15 inches and [illegible] for revegetation purposes. It is recommended that the upper 15 inches of this mapping unit be used for revegetation purposes.

Boron

Boron was analyzed in all these soils to evaluate toxicity problems related to plant growth and production. Hot water soluble Boron was below 1.5 ppm on every soil and it should not restrict plant growth and production. Boron deficiency could occur on some soils when the levels are below 0.5 ppm with certain crops such as alfalfa or corn, but in general, Boron should be adequate for plant growth and production.

pH

pH in general exceeded the value of 7.4 for all the soils. pH values approached 8.6 in some cases which may affect plant growth and production if associated SAR values exceed 12. The soils that exceeded SAR values of 12 were not recommended for final soil cover purposes.

Water Quality Interpretations

The laboratory results indicate which areas and soils may pose potential water quality problems if surface mining were to occur. It is apparent that the Logging Creek soils sampled had by far the most number of reported characteristics exceeding the "red flag" levels. Indian Coulee soils had a moderate number of excessive values, while Buffalo Jump soils did not exceed "red flag" levels at all.

Two important and interrelated factors will affect water quality from surface mined areas: the success of revegetation and water available for deep percolation from precipitation.

The successful establishment of an initial cover crop of vegetation on new mine spoils is the key to preventing erosion and sediment problems. Experience with stripmine reclamation in the West has demonstrated that erosion of freshly regraded mine spoils is generally the most serious water quality problem in the first years following mining. However, revegetation is seriously hampered by several factors.

Relatively low annual precipitation gives little moisture for plant germination and growth. The rainfall that does occur often is in the form of high intensity thunderstorms which have high erosivity power. The fine textured silt and clay loam soils are particularly susceptible to detachment and movement by water. Soil classification erosivity factors (K Values) as given in soil series interpretation sheets are moderate (0.28) to relatively high (0.37) for many reservation soils.[4] Moderate to steep slopes are common and could further contribute to erosion problems.

The Logging Creek and certain soils in the Indian Coulee areas could be particularly susceptible to soil erosion if strip mining occurred. These soils are high in clay content, low in organic matter, and on moderate to steep slopes which will limit water infiltration and availability for plant germination and growth. These same soils are often more saline and high in sodium which can cause crusting and cementation of the soil surface. The Logging Creek and parts of the Indian Coulee areas are in lower precipitation zones (11-13 inches per year) as well.

By field inspection it is not difficult to see that the Logging Creek area and portions of Indian Coulee are naturally some of the most eroded areas on the reservation. If mining were to occur in these areas detailed soil [illegible] special pre-mine reclamation planning and management practices would have to be followed to minimize adverse impacts to water quality.

[illegible] of vegetation on a mined site is important in holding the soil in place, returning the land to a productive status and also minimizing downward percolation of water into mine spoils. McWhorter, et.al. (1977)[2] reported that over 99 percent of the salt load contributed to a watershed by a reclaimed mine spoils area in Colorado came from ground water that had percolated through the saline spoils material. Therefore, prevention of salt loading to surface and ground waters from mined lands as in saline seep areas, is strongly tied to minimizing excess soil moisture available for downward percolation to saturated zones in mine spoils.

On the Northern Cheyenne Reservation, in the three areas sampled, excess soil moisture could result from poor revegetation of mined areas or naturally occurring higher precipitation amounts at higher elevations. The Logging Creek area contains extensive areas of soils that lab results indicate may be difficult to reclaim if mined. Fifteen inches of suitable soil

is the most found in any of the five soils sampled. Most had only six inches or less. It is currently unknown whether any of the deeper overburden may prove to be suitable cover material. Future NCRP testing of core hole and drill cuttings will help determine whether useable overburden material exists. Successful revegetation cannot be counted upon without at least two feet of suitable soil material for a rooting zone. Poor stands or spotty revegetation could result in excess soil moisture being available to leach saline mine spoils. Leachate high in dissolved solids could enter ground waters and later reach drainages such as Logging Creek, Little Coyote or Walking Horse Coulees, and eventually the Tongue River.

High elevation areas such as the Buffalo Jump have soils that appear quite favorable for reclamation purposes. Revegetation appears to have a higher probability of success because of better chemical and organic matter make up and deeper suitable soils. At the same time, this area receives two to four more inches of precipitation each year. Much of this precipitation occurs in the form of later spring snows and early summer thunderstorms, often when surface soils are already saturated or nearly so. Therefore, the possibility of seasonally accumulating excess soil moisture available for deep percolation and leaching of mine spoils exists at higher elevations.

The higher precipitation amounts, of course, could also contribute to successful revegetation of mined lands. In addition, native rangeland at the higher elevations is more productive and has a denser standing crop of grass than lower elevation range. During the growing season, the range grasses at higher elevations will transpire and utilize proportionately more water per unit area than lower elevation rangeland. While higher elevation areas have more soil water available for deep percolation, favorable soils and greater precipitation could allow for

easier revegetation and higher density stands that would utilize more [illegible] balance to some extent, the effects of excess soil [illegible].

In summary, assuming all other pertinent factors equal, the Logging Creek area holds the greatest potential for causing impacts to water quality if surface mining were to occur.

Soils on thin, hilly slopes in the Indian Coulee area also appear to be difficult to reclaim and could cause potential water quality problems if mined. Soils in the Buffalo Jump area are the most favorable of those sampled for reclamation purposes and pose the least threat to water quality if mined.

At this time, the shallow depths of suitable soils in the Logging Creek and parts of the Indian Coulee areas do not appear adequate for necessary rooting depths. Deeper overburden chemistry analysis to be conducted in the near future by NCRP will aid in determining whether additional suitable final cover material can be found. If surface mining were to occur in these areas, special precautions and management practices would likely have to be followed.

<u>Strip Mining Management Practices and Recommendations</u>

Once a mining area were proposed, a detailed soil survey should be done to see whether adequate amounts of chemically and physically suitable soil exist in the proposed area. The proposed area should have enough suitable soil material within it to recover the entire mined area with a minimum of two to eight feet of soil suitable for final cover material. Mined areas should be reclaimed as mining proceeds with not more area than is mined in one year awaiting reclamation at one time.

Pre-mining studies should be undertaken in the proposed mining area to determine natural erosion and sedimentation rates, precipitation,

infiltration, deep percolation and recharge to ground water. Surface and ground water quality in the adjoining area, should be characterized. Native range grass studies and biological inventories should be conducted at least one year previous to mining.

Post-mining reclamation plans, whether developed by the Tribe or a mining company should be designed so as to return the land to a productive state as soon as possible. Reclamation regulations or mining agreements should include objectives and requirements pitched in terms of restoration of the hydrologic balance that formerly existed. Post-reclamation measurements of biological productivity of the replanted area, soil moisture, infiltration rates, ground water [illegible], and surface and ground water quality will help ensure maintenance of water quality on the reservation if mining occurs.

A series of best management practices can be employed in reclaiming any mined area so as to minimize water quality damage. Regrading spoils to the approximate original contour may be good practice except where original slopes are greater than four to one. There is debate among authorities about whether to always require reclaiming mined land to approximate its native condition or whether new land uses such as agriculture should be encouraged. The results of this soil sampling program indicate that any plans to farm reclaimed mine spoil land should be studied very carefully. Soils in the Logging Creek area, for example, may be difficult to crop even before mining because they are naturally thin and saline. Risks of sediment and salt pollution of surface and ground waters could be even greater if soils were left bare through plowing or fallowing. Farming practices such as fallowing or irrigating will greatly increase potential for excess soil water being available for leaching underlying saline spoil material. These leachate waters

could then contaminate local ground water or eventually surface waters. In short, agricultural uses of reclaimed stripmined land could be considered, but should be attempted only on an experimental basis after all sediment and salt sources of pollution are accounted for, mitigated and then monitored.

Spoil piles should be kept away from perennial and major ephemeral stream channels. A buffer zone of unmined area could help protect streams from direct contact with ground water high in dissolved solids found in spoils material.

Detention or holding ponds can be utilized to cut down on sediment transport from mined areas to stream channels. They must, however, be adequately designed to accommodate flood events. They must also be used in conjunction with proper reclamation techniques on the spoils themselves to minimize initial sediment production.

Water diversions around active mining areas can help prevent water accumulating in the pit and pick up of sediment, salts, and metals. Dewatering wells can be located around the pit rather than in it.

A series of surface manipulations on the regraded spoils material can help increase water holding capacity of the soil and availability for plant growth. Dollhopf, Jensen, and Hodder (1977)[7] report that topsoiled mine spoils treated with dozer basins underwent less surface water runoff than other types of treatment.

After considering this report and other studies, the Tribe may designate certain areas as unsuitable for mining based on water quality [illegible] considerations. It is felt that complete pre-mine planning and a successful revegetation program are the two most important factors in minimizing potential water pollution problems.

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COMMUNITY AND LAND USE PLANNING FOR WATER QUALITY

A major task to be performed under the Northern Cheyenne 208 sub-plan was to develop plans for town and rural population growth that would minimize point and non-point pollution of associated streams and groundwater. Several projects were undertaken to address this task:

1. Water quality samples were taken upstream and downstream from the principal communities on a monthly basis and for storm run-off events.
2. A land use mapping and planning effort was undertaken to facilitate decision making and optimum location of community and resource development.
3. Point sources of pollution were identified and sampled. (see point source section.)

This section of the Northern Cheyenne Report addresses the first two items.

Baseline Water Quality Sampling

Monthly chemical water quality samples were collected above and below Busby, Lame Deer, and Ashland, on Rosebud Creek, Lame Deer Creek, and the Tongue River respectively, beginning in May, 1976. A map showing location of sampling sites in shown in Figure 1. A list of the constituents analyzed for and a sample lab sheet is presented in Figure 2. In addition, field measurements were normally taken of temperature, conductivity and pH. Stream discharge or stage measurements taken at the closest gaging station, nearest in time, were paired with water quality data. A special effort was made to take chemical analysis or sediment samples above and below Lame Deer during storm runoff events.

The 208 baseline sampling was designed to augment an already ongoing water sampling program conducted by other NCRP staff under EPA Grant #

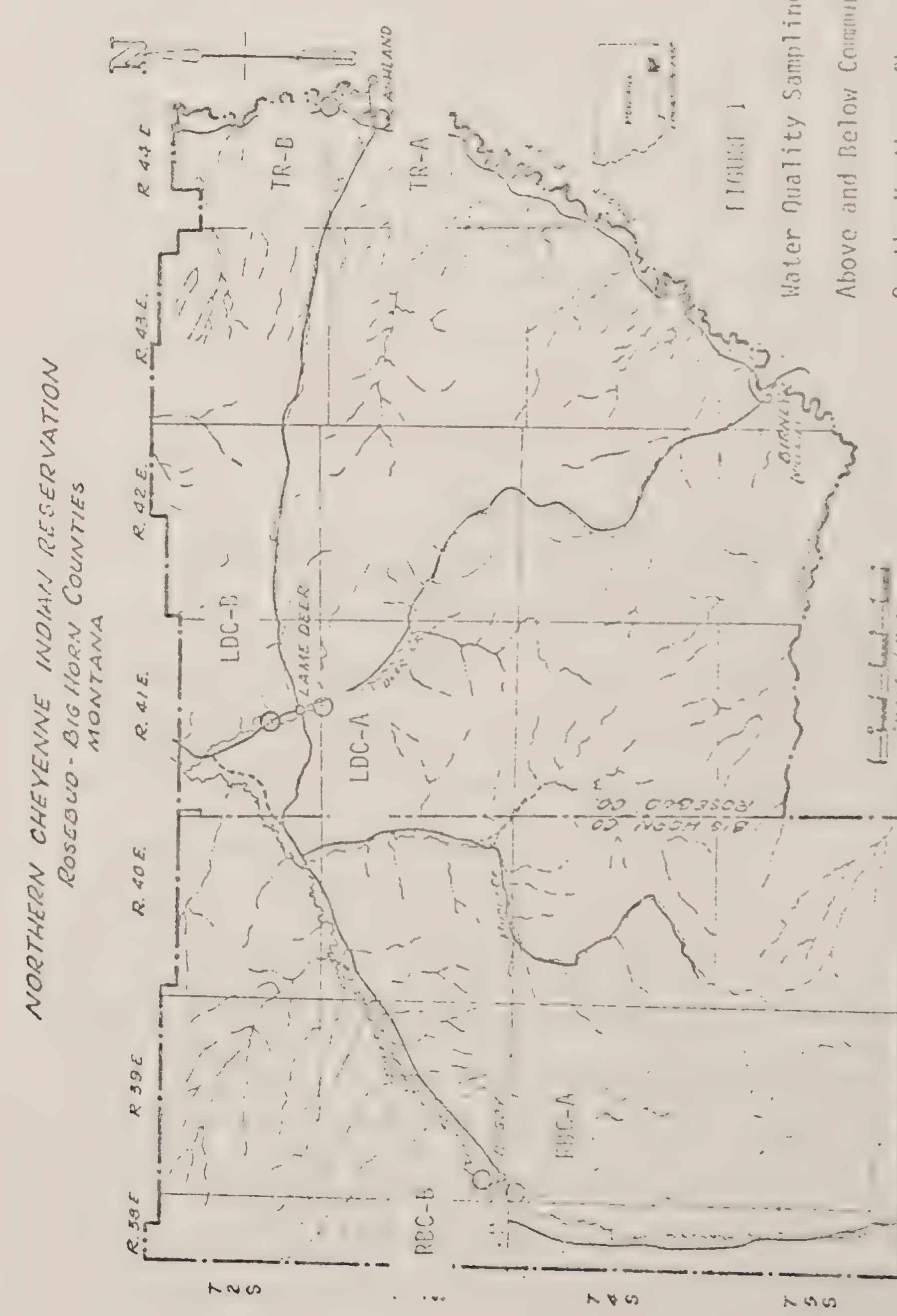


FIGURE 1
Water Quality Sampling Sites Above and Below Communities On the Northern Cheyenne Reservation

Tapuach, Sanderson & Bruun Laboratories

LABORATORY REPORT

Lab. No. 12880-16

To: Northern Cheyenne Research Project   Date 6-25-76

Address 208 Project   General Delivery   Lame Deer, Montana 59043

WATER ANALYSIS

[illegible]
Downstream from Lame Deer @ Hyw. 315
Sampled 6-3-76 11:30AM
Submitted 6-4-76

CONSTITUENT	PARTS PER MILLION	
1. Potassium	10	
2. Sodium	[illegible]	
3. Calcium	72	
4. Magnesium	72	
5. Sulfate	174	
6. [illegible]	[illegible]	
7. Carbonate	0	
8. Bicarbonate	561	
9. Total Dissolved Solids, Calculated	684	
10. Total Dissolved Solids @ 180°C	731	
11. Standard Deviation of Anion-Cation Balance	0.80	Sigma
12. Fluoride	0.9	
13. Silica (SiO_2)	21	
14. Nitrate (NO_3)	3	
15. Total Phosphorus as P	0.09	
16. Total Hardness as $CaCO_3$	478	
17. Alkalinity as $CaCO_3$	460	
18. Non-Carbonate Hardness as $CaCO_3$	18	
19. Conductivity @ 25°C	1,000	micromhos/cm.
20. pH	7.6	
21. Total Suspended Solids	10	

R803566-02, Potential Impacts to Ground Water and Surface Water Quality and Quantity from Proposed Energy Development on the Northern Cheyenne Reservation, Montana, under direction of William Woessner, Hydrogeologist. This program has completed two of three years' work. Under this project, water quality samples are generally collected on streams at the reservation boundaries. Since analysis of metals was conducted on these samples, it was not deemed necessary to run metals on 208 samples. The two projects alos cooperated on collection of sediment samples.

Water samples under 208 were collected every month for the first six months at all stations shown in Figure 1. The results of the first six months were analyzed and the sampling program modified. Since there were no significant differences in average water quality results between stations REC-A and REC-B, and the stations TR-A and TR-B, those sites were sampled only every other month thereafter. Lame Deer Creek stations A and B did have significant differences in average water quality and hence continued to be sampled monthly. Mean water quality constituent concentrations for all samples are shown in Table 1.

As can be seen from the table, mean constituent concentrations for the entire year again showed little or no significant differences for stations on Rosebud Creek above and below Busby, and of those on Tongue River above and below Ashland. Further data comparison reveals little or no significant differences between those stations with regard to total dissolved solids at low flow periods, or suspended solids at high flow periods. Although the data failed to identify either Busby or Ashland as having any significant effect on chemical water quality, they fulfilled their purpose in establishing baseline water quality characteristics as intended. See also the Point Source Section of the Northern Cheyenne 208 sub-plan for discussion of the impacts of sewage lagoon discharges on water quality in Tongue River and Rosebud Creek.

[illegible] ... RESERVATION COMMUNITIES

[illegible], 1976 - April, 1977

[illegible]	[illegible]	[illegible]	DIFF	LDC-A	LDC-B	DIFF	TR-A	TR-B	DIFF
			- parts	per	million	-			
[illegible]	[illegible]	[illegible]	[illegible]	8	10	+ 2	4	4	0
[illegible]	[illegible]	[illegible]	+ 3	54	71	+ 17	36	39	+ 3
[illegible]	[illegible]	[illegible]	+ 5	[illegible]	111	+ 26	62	65	+ 3
[illegible]	[illegible]	[illegible]	[illegible]	57	35	- 2	35	35	0
[illegible]	[illegible]	[illegible]	+ 113	[illegible]	179	+ 41	160	175	+ 15
[illegible]	[illegible]	[illegible]	-	[illegible]	14	+ 6	8	7	- 1
[illegible]	[illegible]	[illegible]	+ 4	24	14	- 10	4	4	0
[illegible]	[illegible]	[illegible]	- 1	[illegible]	537	+ 78	230	238	+ 8
[illegible]	[illegible]	[illegible]	+ 10	638	741	+ 103	454	472	+ 8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.85	+0.05	0.25	0.35	+ 0.1
[illegible]	[illegible]	[illegible]	- 2	19	21	+ 2	4	4	0
[illegible]	[illegible]	[illegible]	[illegible]	0.8	2	+1.2	1	0.5	- 0.5
[illegible]	[illegible]	[illegible]	+0.08	0.08	0.4	+0.32	0.04	0.05	+ 0.01
[illegible]	[illegible]	[illegible]	+ 15	445	503	+ 58	296	304	+ 8
[illegible]	[illegible]	[illegible]	+ 7	12	47	+ 35	38	37	- 1
[illegible]	[illegible]	[illegible]	0	[illegible]	8.0	-0.1	8.1	8.1	0
[illegible]	[illegible]	[illegible]		12	13		9	10	
[illegible]	[illegible]	[illegible] °C		3-19°C	3.5-27		3.7-26°C	1-23°C	
[illegible]	[illegible]	[illegible]	28	714	791	+ 77	490	494	+ 4
[illegible]	[illegible]	[illegible]	+ 0.2	7.1	7.6	+ 0.5	7.7	7.7	0
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		401	401	

[illegible] below Lame Deer [illegible]

[illegible], 4 miles north of Ashland near reservation line

[illegible] concentration of 1212 ppm, 7-27-76, next highest is 253 ppm

Lame Deer Creek appears to have significant differences in certain baseline water quality characteristics upstream and downstream from Lame Deer. Mean annual concentrations reported in Table 1, indicate there are increases in dissolved solids, nutrients and suspended sediment, downstream from Lame Deer.

Total dissolved solids (TDS) increased an average of 103 ppm downstream from Lame Deer. As referred to in the point source section, the majority of this increase is thought to be caused by groundwater contribution to Lame Deer Creek. Sulfate and bicarbonate comprised the greatest share of the dissolved solids increase, and are ions common to alluvial groundwaters in this area. With low flow conditions, the entire creek becomes influent within Lame Deer and re-emerges in a marshy discharge area just south of Highway 212 in Lame Deer. Numerous springs and seeps can be seen in this area. Effluent from the Lame Deer sewage lagoon is known to be high in TDS, but a portion of this dissolved load also orginates from two large springs discharging directly into the bottom of the lagoons.

Nutrient concentrations of nitrate (NO_3) and phosphorus (as P) also increased downstream from Lame Deer. This may be attributed to a combination of several sources: The Lame Deer sewage lagoon effluent, septic tank seepage, animal wastes or elevated nutrient levels in the groundwater. Seepage from septic tanks or privies is estimated to be possible but of limited occurance. Most homes with private waste disposal systems are upstream from the point where Lame Deer Creek enters the marsh area. The marshy, intervening area provides a good biological filter for removing nutrients that may reach the creek. There is pasture land between Lame Deer and the LDC-B sampling station. Nutrient contribution from animal wastes could occur directly to the creek, and during storm runoff events

or snowmelt. Indirectly, nutrients of animal origin can be reaching the alluvial ground water and re-entering surface waters in springs or baseflow.

Examination of water quality data for the wells supplying the public in Lame Deer reveals somewhat elevated nitrate levels in the Lame Deer valley alluvium ground waters. Four of six samples had nitrate levels of 6 to 7.6 ppm. However, a water supply inventory conducted by the Indian Health Service [illegible] 76, found a result of 2 ppm nitrate for tap water from the Lame Deer public supply wells. The wells are in valley fill clinker alluvium at a depth of 80 feet. It is possible that the increase in nutrients in Lame Deer Creek is caused by the addition of ground water that has elevated nitrogen and phosphorus levels to baseflow. The sources of the nitrate and phosphorus are not clearly known.

In Crazy Heads Springs the major source of NO_3 and P in the spring water could only be attributed to leaching of animal waste to the ground water system (see pond water section). This again may be the most likely source of nutrients in the Lame Deer Valley ground water.

The final possible cause of nutrients in Lame Deer Creek would be from the sewage lagoons. As indicated in the point source section however, possibly up to 75 percent of the lagoon effluent is composed of ground water seepage to the lagoons. It is difficult to assess the share of nutrients that originate from sewage influent or ground water. A sample of sewage influent taken July 26, 1976 in a manhole just before the main sewer line empties into the lagoon, gave 4.0 ppm NO_3 and 8.5 ppm total P. Two samples of lagoon effluent were collected: 14.0 ppm NO_3 and 2.2 ppm total P, taken November 22, 1976, and 1.0 ppm NO_3, 2.6 ppm total P, taken January 4, 1977. Higher nutrient concentrations in lagoon effluent would be expected in winter when little biological or vegetation growth occurs that utilizes nitrogen and phosphorus. Although the Lame Deer sewage lagoons could be considered

another likely source, they are located in a groundwater discharge area. Under current hydrologic conditions, it does not appear likely for the lagoons to be seeping nutrients laden waters to the ground water system.

The data indicate that the majority of nitrate addition to Lame Deer Creek comes from groundwater sources, while the majority of phosphorus addition comes from domestic wastewater in the Lame Deer sewage lagoon effluent.

The concentrations of nutrients in the effluent and proportion contributed by groundwater and waste water will change with the seasons and biological efficiency in the lagoons. Water quality data from a NCRP sampling station near the mouth of Lame Deer Creek, 2.5 linear or about 6 stream miles downstream from the LDC-B station show reduced concentrations of nitrate and phosphorus. At the LCD-B station, nitrate averaged 2 ppm and total phosphorus averaged 0.4 ppm. At the downstream station near the mouth of Lame Deer Creek, nitrate averaged 1.7 ppm and total phosphorus averaged 0.25 ppm. Natural aquatic and vegetation growth in the creek appear to be reducing nutrient concentrations downstream. Irrigation of hayfields in the Lame Deer Creek valley occurs using creek water in flooding and spreader dike systems. This may also reduce nutrient concentrations in subsurface return flows to the creek. Little or no commercial fertilizers are known to be used in that area. In summary although somewhat elevated levels of nitrate and total phosphorus do occur downstream from Lame Deer, concentrations are not harmful to any beneficial use and may benefit irrigation to some extent.

Total suspended solids (TSS) concentrations also increased downstream from Lame Deer. Mean TSS above Lame Deer was 12 ppm, while mean TSS downstream from town was 47 ppm. This increase is most attributable to general non-point source contribution from Lame Deer,

primarily from unpaved streets. The only point source, the sewage lagoons, had discharge effluent very low in suspended solids. Two tests gave 14 and 26 TSS in the sewage lagoon effluent. Some stream bank erosion may occur in this reach of stream. However, since most of this stretch of Lame Deer Creek is a marshy discharge area, stream bank erosion is normally quite minimal.

The LDC-3 suspended solids mean was driven upwards by two baseline samples, 113 ppm on 06-24-76 and, 314 ppm on 11-21-76. In the first instance, precipitation records indicate rain had fallen on that day. The Lame Deer precipitation gage was manfunctioning on the other occassion.

Besides the two major highways, U.S. 212 and Montana 315, that bisect Lame Deer, there are only a few paved streets. Certain areas under construction projects have been known to be sediment sources. The many unpaved streets and driveways are the biggest continuous source however. Storm runoff and snowmelt from these areas of bare soil cause great increases in sediment loads of Lame Deer Creek. Storm water sampling was undertaken to determine the magnitude and sources of the problem.

Four different storm runoff events were sampled to determine impacts to Lame Deer Creek form urban non-point sources of pollution. Sediment data from these samples are presented in Table 2.

TABLE 2

Total Suspended Solids Concentrations in Lame Deer Creek Following Selected Storm Run-off Events, 1976-77.

	PPM			INCHES	CFS	TONS/DAY
DATE	ABOVE LAME DEER	IN LAME DEER	BELOW LAME DEER	24 HOUR RAINFALL	LAME DEER CREEK DISCHARGE	SEDIMENT LOAD
5-11-76	4	108	18	0.25	5.1	1.[illegible]
6-14-76	32	-	348	1.55	-	-
6-24-76	16	-	113	0.94	-	-
5-18-77	9	692	51	-	2.5	4.67

On two occassions, sediment samples were taken of Lame Deer Creek within Lame Deer and both times these concentrations were hicher than those found one-quarter mile downstream from Lame Deer [illegible] NCRP sampling station. High stormwater sediment concentrations reached their peak in Lame Deer at the Highway 212 bridge. Apparently, substantial deposition of suspended solids occured in the one-quarter to one-half stream miles between the Highway 212 bridge and the Highway 315 bridge. even more deposition occurs further down stream as indicated by the 5-11-76 sampling result of only 18 ppm below Lame Deer which was about 3 miles downstream from Lame Deer.

From available data, it appears that baseflow sediment loads in Lame Deer Creek at Lame Deer range from 0.01 to 0.5 tons per day. Storm runoff sediment loads in Lame Deer Creek normally rance from 1 to 5 tons per day.

Two samples of gutter runoff were taken in the May 11, 1976 storm event. One major stormwater ditch that drains the tribal office parking lot area contained 2150 ppm suspended solids. Samples taken up and downstream from this gutter showed an increase of only one ppm total suspended

[illegible] draining Highway 212 and adjacent areas contained 5270 ppm TSS. Just below the Highway 212 bridge, Lame Deer Creek contained 108 ppm TSS.

Chemical analyses were also conducted on samples from the May 11, 1976 storm event. The only noteable deviations from normal chemical constituent concentrations were 3.9 ppm iron and 50 ppm silica in the tribal office area runoff. This iron concentration is extremely high for surface waters and indicated some metal contamination. Certain groundwaters do contain similar concentrations of iron.

In summary, sediment pollution of Lame Deer Creek from storm runoff events on unpaved streets is a relatively serious problem. Sediment levels increase from 10 to 100 times base flow levels in Lame Deer Creek during storm runoff events. Sediment problems are somewhat isolated to the Lame Deer area because deposition occurs along the marshy streambank.

The most desireable solution to the sediment problem is to pave the streets in Lame Deer. An effort by the tribe is underway to allocate congressional funds for this purpose. Conflicts in jurisdiction over the Lame Deer townsite between the tribe and Rosebud County complicate matters. Health and safety reasons as well as water quality reasons call for paving streets and installing curb and gutter in Lame Deer.

Land Use Planning and Water Quality

Community and resource development can have significant impacts on water quality. On the Northern Cheyenne Reservation, new housing construction is underway and future development of timber or coal resources is possible. The Northern Cheyenne 208 Program in cooperation with other NCRP staff initiated a land use mapping and planning program for the reservation to assist the tribe in land use decisions. The mapping effort consisted primarily of developing mylar overlays of different land and resource features to fit all of the U.S. Geological Survey 7.5 minute quadrangle maps for the reservation. The planning effort involved numerous meetings and contacts with various agencies and organizations involved in housing or land use. A tribal land use planning advisory committee was organized and additional planning staff hired by the NCRP to administer a homesite surveying and master plan development contract for the tribe. Planning for maintenance of water quality involves many facets of land and water use. As a result, the 208 study played a part in starting comprehensive land and resource planning on the Northern Cheyenne Reservation. A detailed description of the land use planning program on the reservation is contained in a report by James K. Streeter (1977), entitled: "Land Use Inventory: A Case Study of Land Use Planning on the Northern Cheyenne Reservation".

One of the principal issues involving land use planning and water quality was the location of suitable areas for rural homesites on the reservation. Over 150 homes have been built in rural areas on the reservation since 1972 and an additional 100 new homes are planned for the next one year period. Population figures showing a continual increase in recent years with a relatively youthful average age suggest a need for more housing

[illegible] . According to Housing Authority files, an application [illegible] 10 more units of Mutual Help Housing and another 25 Elderly Housing [illegible] been filed with an additional 150 Mutual Help to be filed in 1978. [illegible] are 100 units of Mutual Help currently under construction.

The prevailing trend towards rural homes on private septic systems [illegible] for information on suitable building sites. Discussions with various organizations and individuals on the reservation indicated that homesites should be located in keeping with overall tribal [illegible] ning goals. As a result, a series of map overlays were developed for all 26 USGS quad maps of the reservation depicting pertinant resource or planning features. The following overlays were prepared and examples appear in Figures 3 through 8 :

1. Housing and Public Facilities
2. Land Ownership Status
3. Existing Agricultural Land
4. Suitable Homesite Areas
5. Potential Agricultural Land

Two overlays were prepared under a seperate contract from the BIA to the tribe. These are the soils overlay and grass overlay, Figures 9 [illegible] 10. The NCRP initially assisted in the preparation of these overlays by evaluating mapping results and suggesting changes. Later, the NCRP was [illegible] the local supervisor of work under this contract. The final overlay [illegible] tled "Forest Stratification and General Land Use", (Figure 11) was prepared by the Raytheon Company under a seperate BIA contract.

When used in combination, the overlays permit locating suitable home-[illegible] areas that have soils suitable for septic tanks and that minimize other [illegible] conflicts. In this manner, water quality as well as other resource [illegible] can be protected.

The updated soils, grass and land ownership status overlays will permit more accurate determinations of grazing [illegible] and landowners. Efficient resource management [illegible] over-lays can minimize non-point sources of pollution by determining equit-able grazing fees and distribution of livestock.

The potential agricultural land overlay is based on soils suita-bility and topography constraints. When properly used and interpreted with other resource data, this information can assist in planning dry land or irrigated agricultural land development. Areas of saline or poorly drained soils can be generally located and water quality considerations taken into account in agricultural development. This has been particularly important in the recently planned expansion of the tribal sprinkler ir-rigation project along the Tongue River on the reservation.

The forest resources overlay, although produced under a seperate con-tract, is an additional vital overlay for many purposes including sound timber management, location of timber sales and logging roads, forest fire control and watershed management activities. The BIA Forestry Office in Lame Deer has been utilizing these overlays in their forest management and planning.

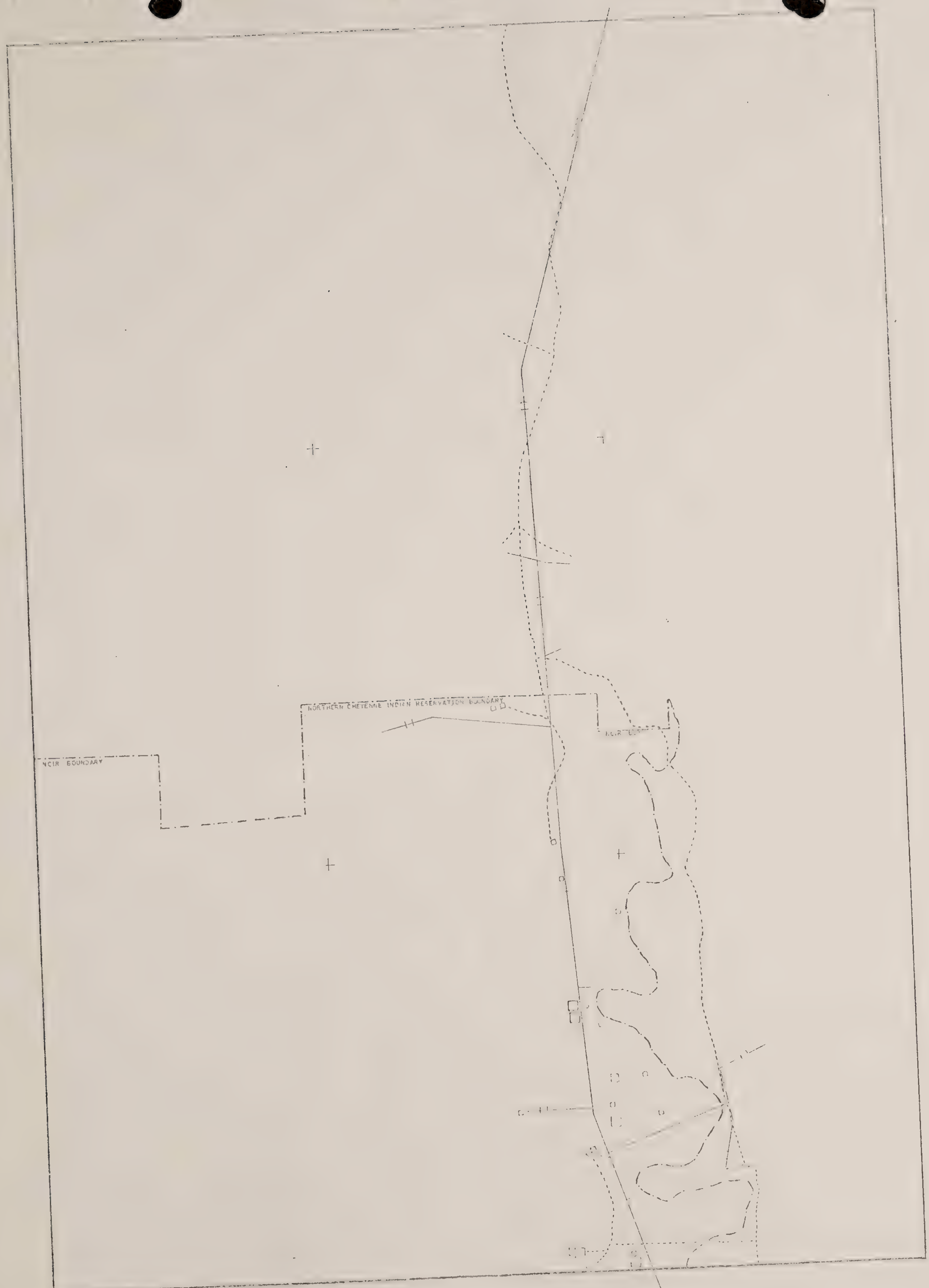
Future maps and overlays can include ground water development potential and geology. Further research by the NCRP will permit generalized ground-water yield and quality maps to be prepared that would greatly assist in location of homesites considering groundwater supply and quality. Such in-formation is greatly needed by farmers, ranchers and tribal agencies in planning agricultural water developments. In combination with geologic overlays, groundwater maps would aid the tribe in assessing potential im-pacts to ground and surface waters from coal strip mining activities.

These maps and overlays are currently being utilized in a first step toward implementation of sound land planning and water quality goals on the reservation via the tribe's contract for surveying and real estate development mapping (BIA No. C50C14204764). These materials are being utilized to guide surveying and location of future rural homesites and community subdivisions in the Lame Deer, Busby, Birney Village, and Muddy Cluster areas.

It is recommended that the Tribal Land Use Planning Advisory Committee and Tribal Land Use Planner work to develop homesite location criteria in keeping with the overall needs of both homeowners and land users such as stockmen, forestry, and other tribal resource plans. The criteria should include minimum setbacks from perennial streams, septic tank siting, and sizing guidelines, and preventing erosion from driveways and vehicle access roads.

The use of these maps and overlays in combination with the input of the tribal land use planning advisory committee can guide decisions by the tribal council regarding land and water development on the reservation in keeping with water quality maintenance goals and the desires of the Northern Cheyenne People.

Figure 3



LEGEND

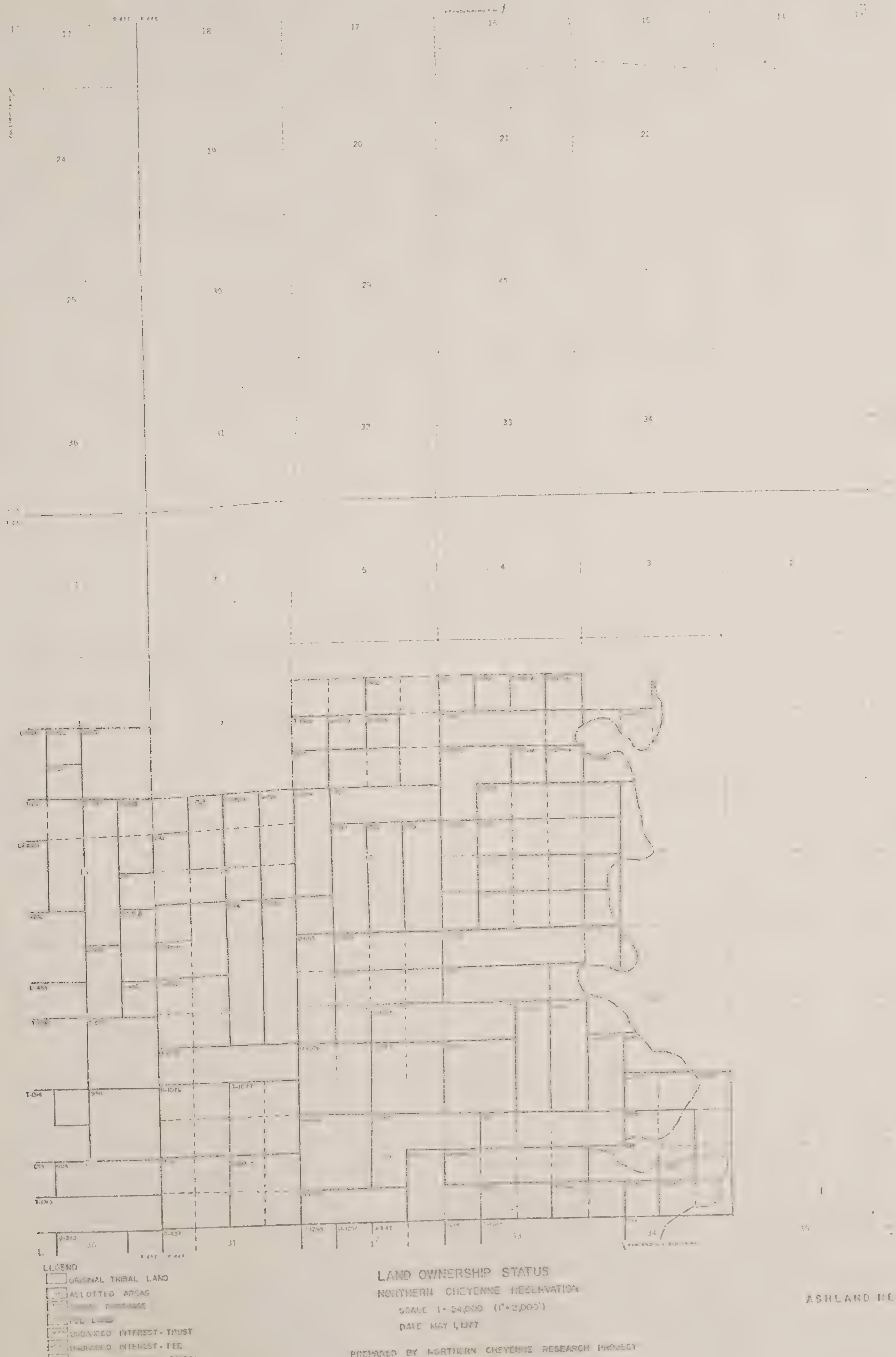
- 2.5 ACRE NEW HOMESITE
- HOMESITE SINCE 1966
- TRAILERHOUSE
- ORIGINAL BUILDING BEFORE 1966
- POWER TRANSMISSION LINES
- TELEPHONE LINES

HOUSING & PUBLIC FACILITIES
NORTHERN CHEYENNE RESERVATION
SCALE 1:24000 (1" = 2,000')
DATE JANUARY 1, 1977

ASHLAND NE.

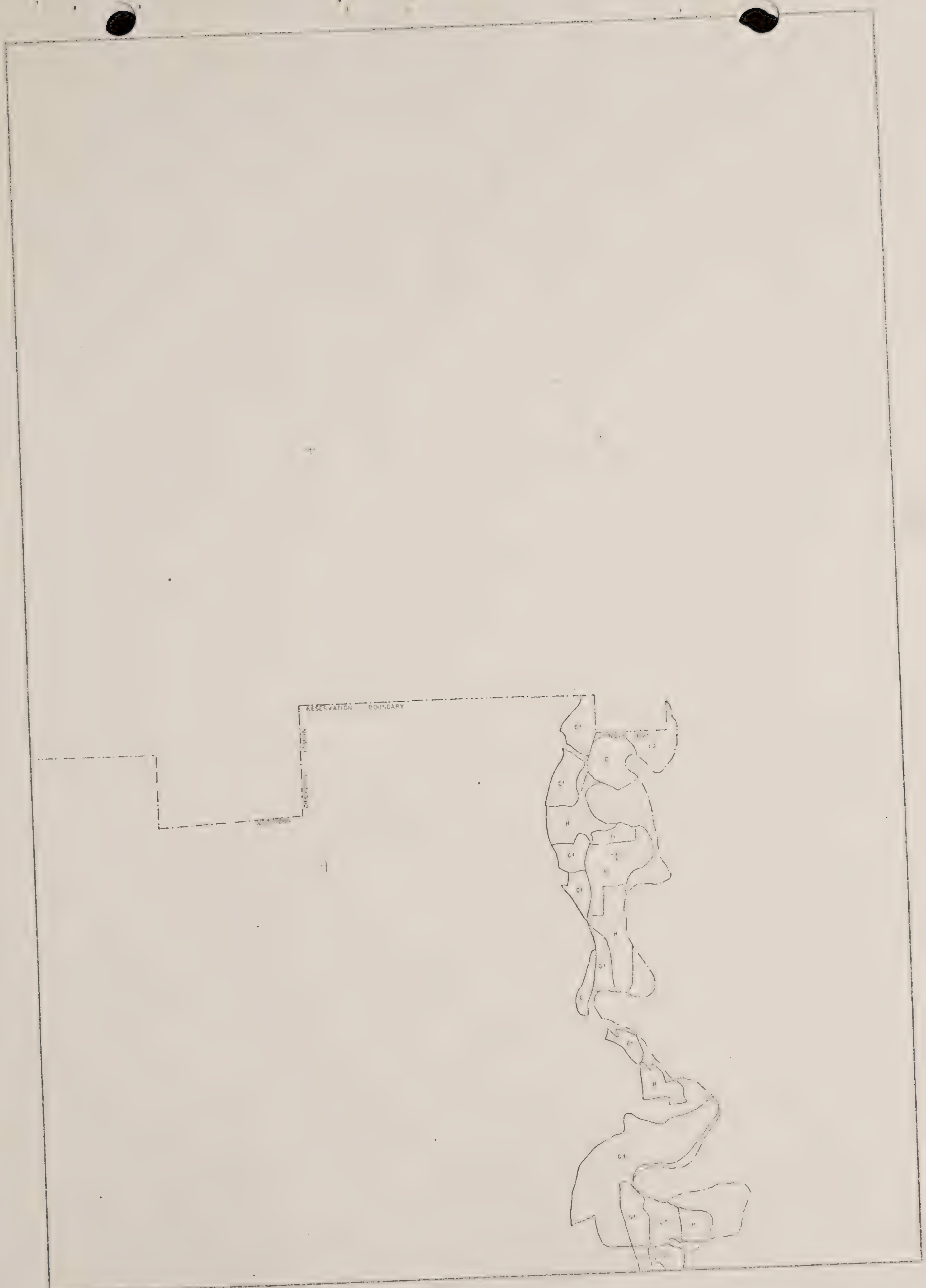
PREPARED BY NORTHERN CHEYENNE RESEARCH PROJECT

Figure 4



LEGEND
ORIGINAL TRIBAL LAND
ALLOTTED AREAS
FEE LAND
UNDIVIDED INTEREST - TRUST
UNDIVIDED INTEREST - FEE
UNDIVIDED INTEREST - TRIBAL
LAND OWNERSHIP STATUS
NORTHERN CHEYENNE RESERVATION
SCALE 1:24,000 (1"=2,000')
DATE MAY 1, 1977
PREPARED BY NORTHERN CHEYENNE RESEARCH PROJECT
ASHLAND NE

Figure 5



LEGEND

GRAIN-FALLOW

PASTURE

IRRIGATED HAYLAND

IRRIGATED GRAIN

IRRIGATED PASTURE

OVERFLOW

SUBIRRIGATED

EXISTING AGRICULTURAL LAND

NORTHERN CHEYENNE RESERVATION

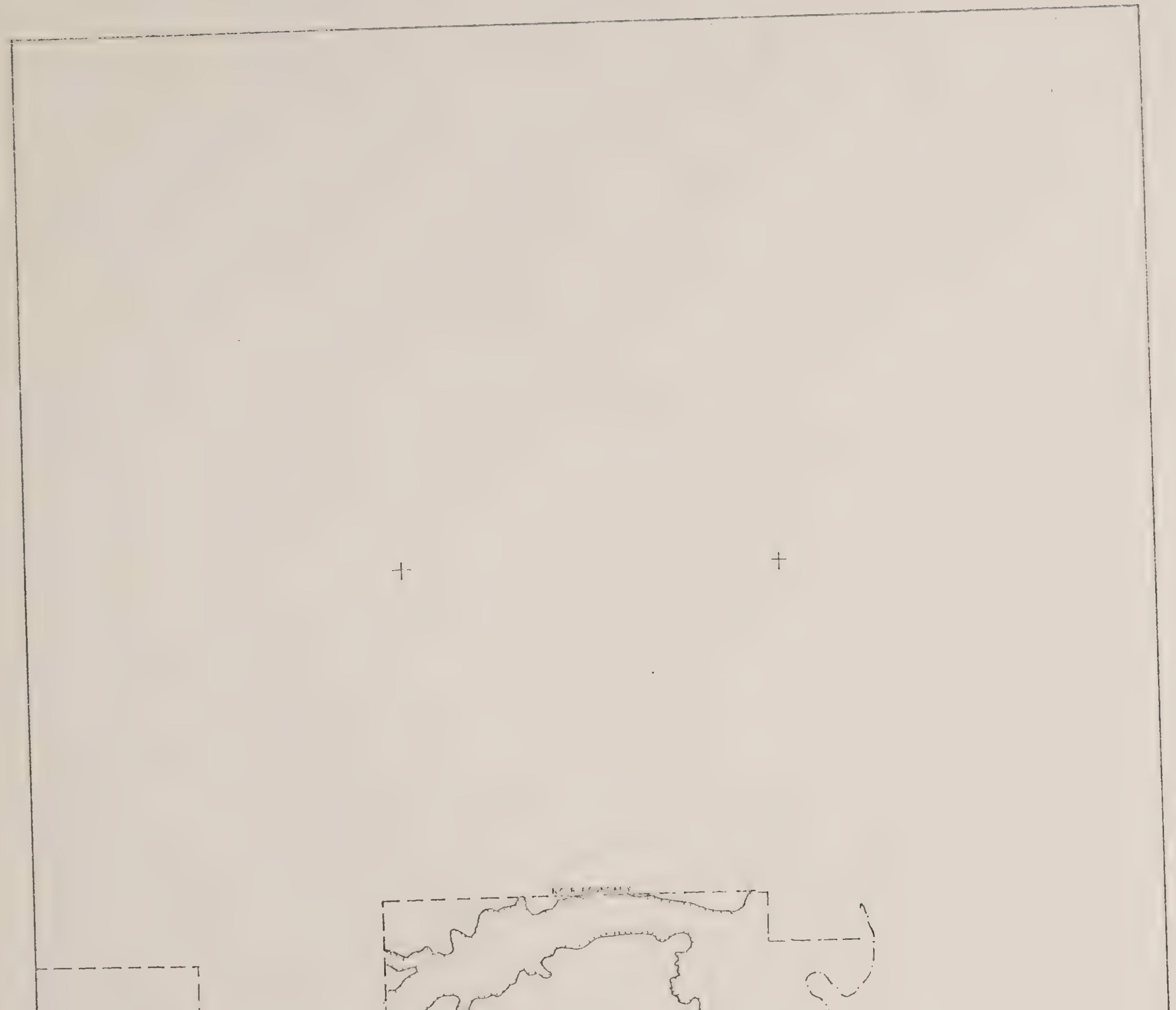
SCALE 1:24,000 (1" = 2,000')

DATE JULY 1, 1977

PREPARED BY NORTHERN CHEYENNE RESEARCH PROJECT

ASHLAND N. E.

Figure 6



REFERENCE:

LEGEND

MODERATE SOIL LIMITATIONS FOR SEPTIC TANK SUITABILITY AND DWELLING CONSTRUCTION

SUITABLE HOMESITE AREAS

NORTHERN CHEYENNE RESERVATION

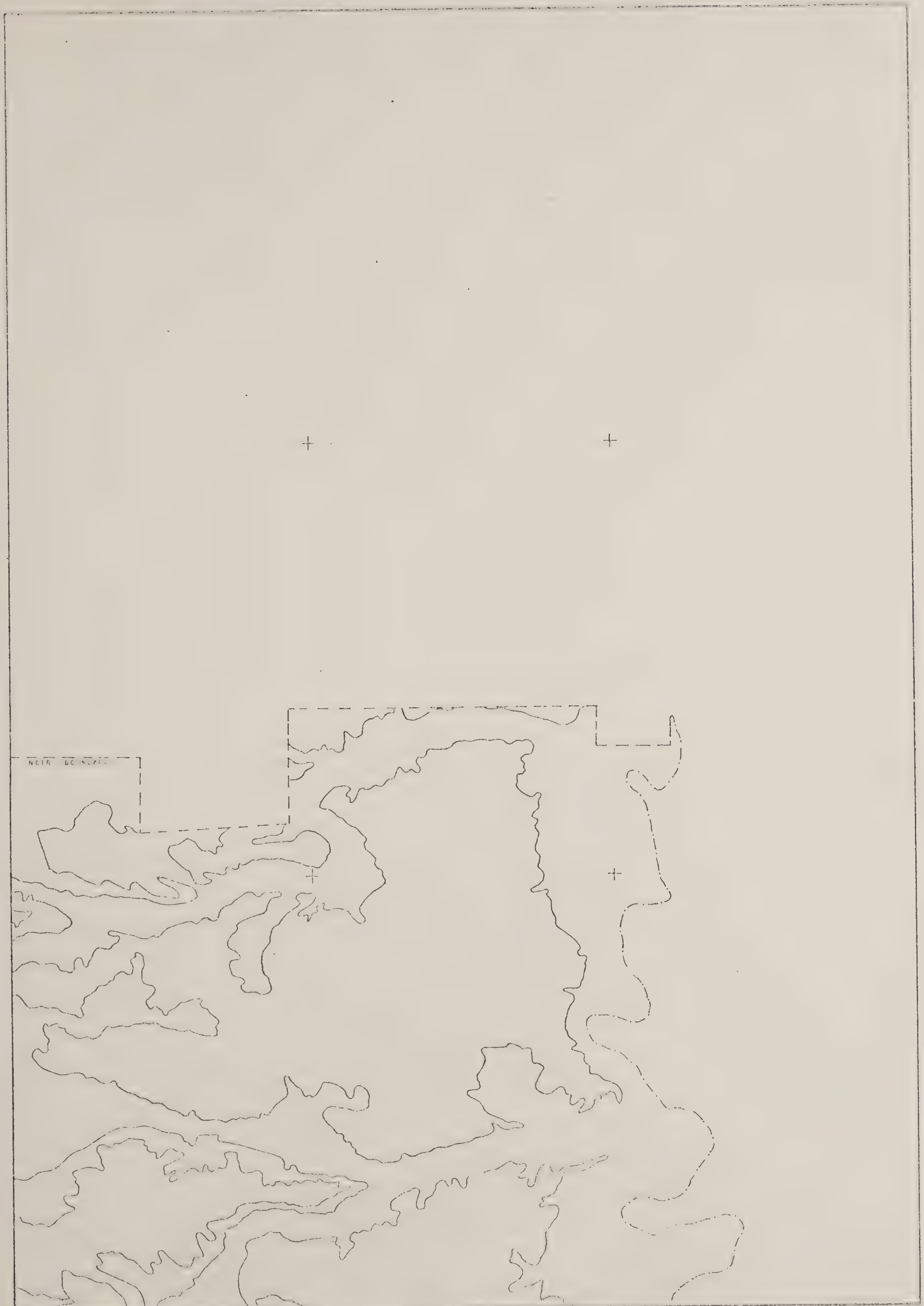
SCALE 1:24000 (1"=2,000')

DATE JANUARY 1, 1977

PREPARED BY NORTHERN CHEYENNE RESEARCH PROJECT

ASHLAND NE

Figure 7

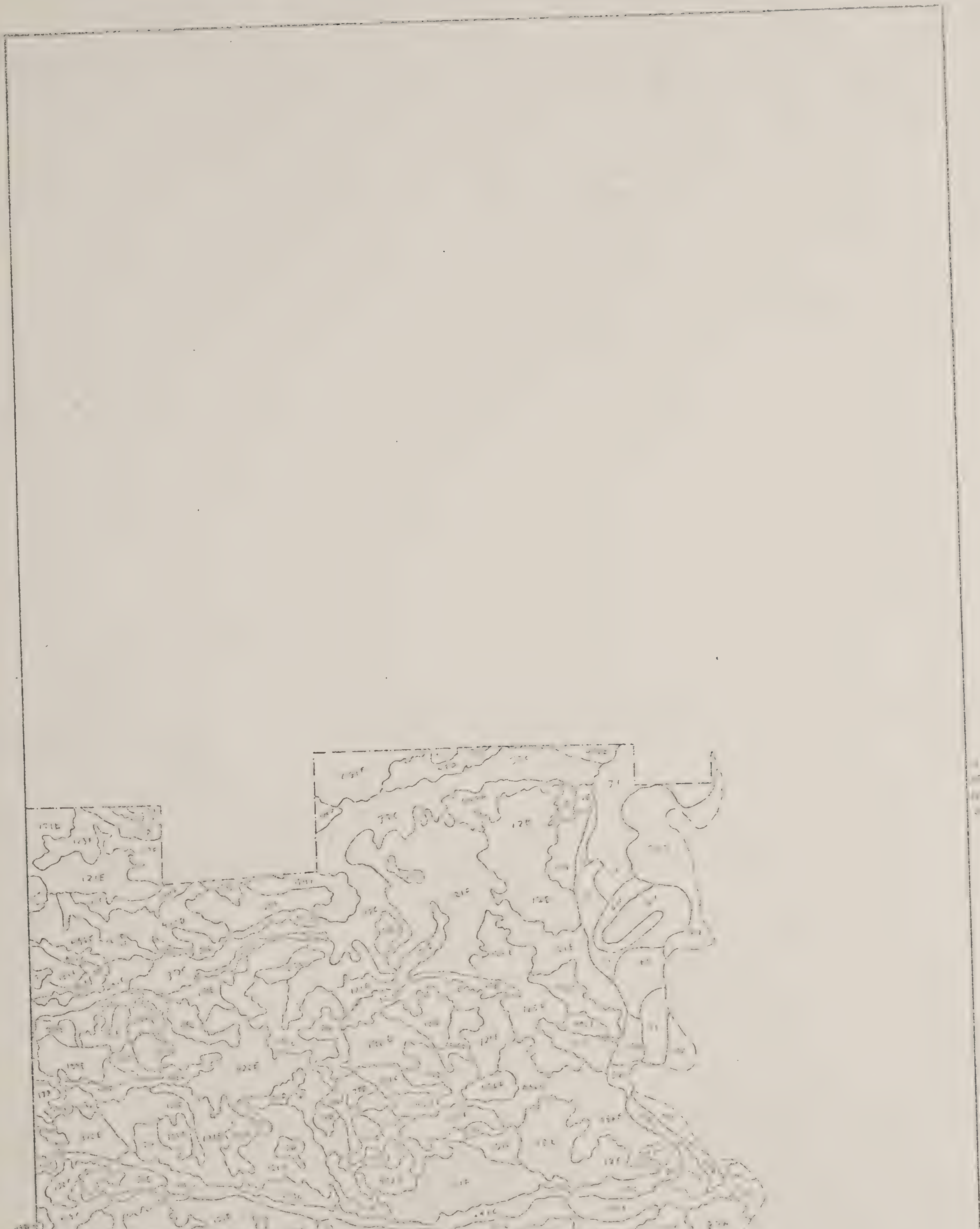


POTENTIAL AGRICULTURAL LAND
NORTHERN CHEYENNE RESERVATION
SCALE 1:24,000 (1"=2,000')
DATE JANUARY 1, 1977

ASHLAND NE

PREPARED BY NORTHERN CHEYENNE RESEARCH PROJECT

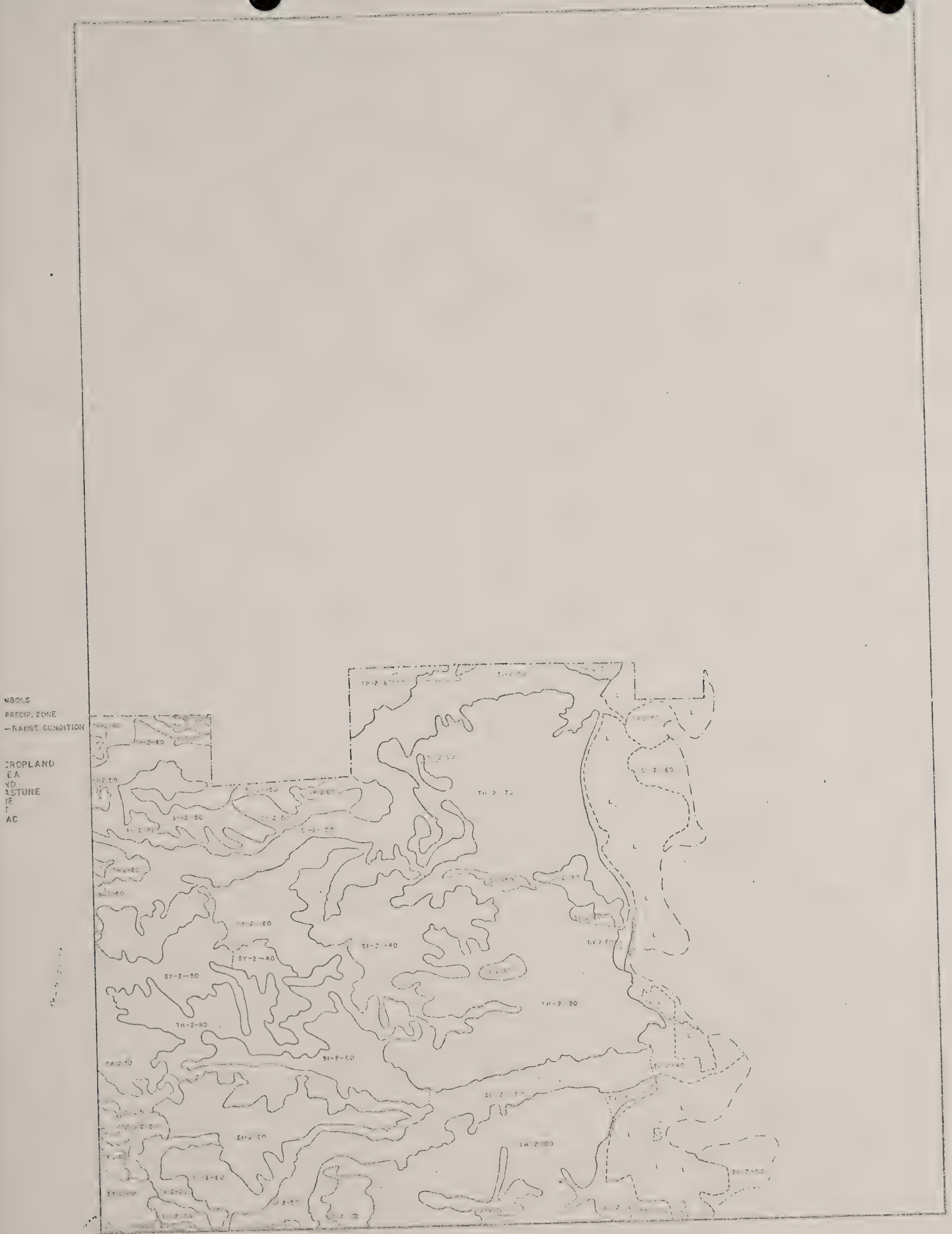
Figure 8



RANGE & SOIL INVENTORY
NORTHERN CHEYENNE RESERVATION
KEYED TO ORTHOPHOTO QUAD.
AT A SCALE OF 1"-2,000'
DATE OF INVENTORY 75-76

SOIL OVERLAY
ASHLAND N.E.MONT.

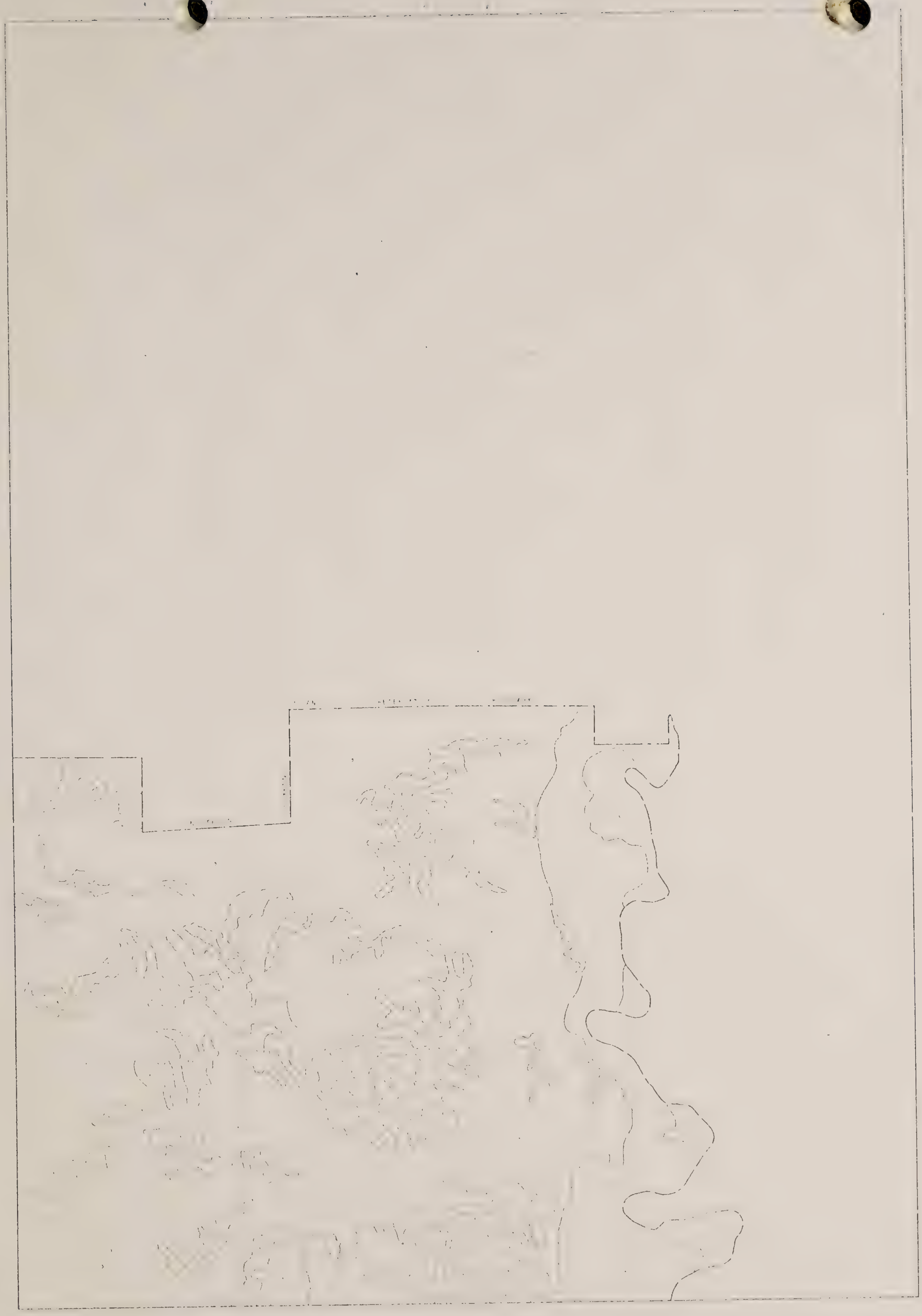
Figure 9



RANGE & GRASS INVENTORY
NORTHERN CHEYENNE RESERVATION
KEYED TO ORTHOPHOTO QUAD.
AT A SCALE OF 1"= 2,000'
DATE OF GRASS SURVEY AUG. 1976.

GRASS OVERLAY
ASHLAND,NE.
MONTANA.

Figure 10



PREPARED FOR:
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF INDIAN AFFAIRS
BILLINGS, MONTANA

PREPARED BY:
RAYTHEON Autometric
WAYLAND, MASSACHUSETTS

NATURAL RESOURCES INVENTORY
CROW AND NORTHERN CHEYENNE RESERVATIONS

KEYED TO ORTHOPHOTO QUAD SHEETS
AT A SCALE OF 1"=2000'

DATE OF INVENTORY: 1973–1974

ASHLAND NE,
MONTANA

FOREST STRATIFICATION
AND GENERAL LAND USE

Figure 11

Many communities across the country have discovered, often too late, that dumps, junkyards and other solid waste disposal sites can adversely affect water quality. There have been no reported cases of waste disposal sites on the Northern Cheyenne reservation adversely affecting water quality. It is possible however, that there may have been cases not reported or that problems may show up in the future.

The reservation has two principal solid waste disposal sites, one in Lame Deer and another in Busby, and several small unofficial dumping sites. [illegible] 1 site, two miles west of Ashland, was closed by the Tribe [illegible].

The Lame Deer disposal site is the largest and serves the most population. It is situated one-half mile northeast of Lame Deer and at the head of a small [illegible]. The elevation of the site is 3460 feet, compared to the 3300 foot elevation of Lame Deer Creek. The drainage does not sustain an active stream at any time during the year. The disposal site is a minimum of 3500 feet from Lame Deer Creek. There likely is some surface water drainage during brief periods of intense snowmelt or heavy spring thunderstorms. This drainage has not been observed contributing direct runoff into Lame Deer Creek. A broad [illegible] an area lies between the mouth of the drainage and the creek.

One of two Lame Deer public water supply wells is located about 1600 feet south of the Lame Deer waste disposal site. Several other domestic wells are in the Alderson Creek tributary of Lame Deer Creek, and are down slope from the waste disposal site.

Preliminary examination of the situation indicates that there is a potential for contamination of these domestic wells from the Lame Deer waste disposal site. The elevation of the disposal site directly upslope from the wells and

the continual heavy pumping at the Lame Deer public supply well give cause for concern. The public supply well is [illegible] valley-fill material. Several other domestic wells nearly are finished in the same material at 60 to 100 feet. Ground water movement through rock and soil material occurs quite slowly and is usually measured in inches or feet per year. It is possible that although pollution of wells has not yet occurred, contaminated ground water could be traveling toward the wells.

Water quality samples taken since December, 1975, have not indicated any contamination. All parameters tested were under recommended limits of the U.S. Public Health Service. The Lame Deer public water supply was tested in February, 1977, under the U.S. Environmental Protection Agency's special drinking water analyses program. All parameters tested were under recommended standards.

Not enough information is currently available to determine whether future contamination problems may develop. It is unknown whether there is [illegible]-plus soil moisture available for leaching on an annual basis. The depth of the unsaturated zone below the disposal site is not known. The geologic make-up in the 100 feet of material between the elevation of Alderson Creek and the site is also unknown. A series of observation wells would be needed around the disposal site and water quality samples taken. A considerable amount of time and money would likely be required.

While the current Lame Deer disposal site is certainly convenient to town residents and fulfilled its purpose for many years, it is recommended that work begin on locating potential new sites. In addition to possible water quality concerns, the present site blocks the expansion of both needed cemetery space on the south and future homesites or public facilities on the west.

It is recommended that the Tribal Land Use Planning Advisory Committee and new land use planner initiate studies of the solid waste needs on the reservation, locate potential new waste disposal sites and techniques to reclaim the existing Lame Deer site.

The Busby solid waste disposal site is located in the northwest one-quarter of section five, township 4S, range 39E, about one mile southeast of Busby. It is in the Busby Creek drainage, an ephemeral stream, about one mile above its confluence with Rosebud Creek. It's elevation is 3530 feet compared with the 3470 foot elevation of Busby Creek. The site is about 1000 [illegible].

The nearest domestic wells are approximately 1500 to 2000 feet distant. Two are finished in Busby Creek sand and gravel alluvium at 43 and 73 foot depths. One is finished in sand at 80 feet and another in sandstone at 320 feet.

Ground water pollution of these wells does not appear to pose a serious threat with the limited information available. The Busby waste site is relatively small and does not appear to be located in a significant recharge area for the aquifers involved. Again, the availability of surplus soil moisture for leaching and geologic strata underlying the Busby site are not specifically known. It is recommended that the Busby waste disposal site be examined by the Tribal Land Use Planning Committee along with the overall solid waste needs of the reservation.

There is a continuing need for reservation-wide planning and management of solid waste. Currently, Ashland area residents are without an on-reservation public waste facility. Both collection and landfill techniques need to be upgraded. Older dump sites need to be reclaimed. With the increasing rural pop-

ulation on the reservation, new waste management systems could be eventually needed. The comprehensive study required for this task is beyond the scope of the 208 report. However, some groundwork has been prepared and a tribal land use planning program started that will facilitate examination and solution of the problems.

Preventing contamination and mixing of ground water aquifers is recognized as a very important measure to maintain the best possible ground water quality. On the Northern Cheyenne Reservation, this was dramatized by the intensive geologic exploration and drilling by coal companies that occurred in the 1960's and early 1970's. The Peabody Coal Company drilled up to 100 exploration holes per square mile in places.

Subsequent inspection by the Tribe showed that many holes were improperly plugged or not plugged at all. The Northern Cheyenne Landowners Association, directed by the late Dave [illegible], undertook efforts to get the appropriate companies to properly plug holes and pay for damages. This matter remains to [illegible].

It is recommended that the Northern Cheyenne Research Project and Tribal Land Use Planning Advisory Committee work with the Landowners Association and Tribal Council committees to pursue the matter of hole plugging. The Tribe may also want to consider adopting recommendations contained in the YTAPO 208 report concerning proper drill hole plugging techniques for any new drilling undertaken on the reservation.

It is also recommended that the NCRP, Land Use Committee and Landowners Association examine existing water quality data and field conditions relating to flowing or artesian wells and abandoned wells. These should be evaluated to see if there are any problems of surface or ground water contamination by low quality artesian water. Recommendations by these groups can be made to the Landowners Association, Livestock Association or Tribal Council for implementation. Funds for farm and stock well improvements could come from the BIA through its Range and Soils office or "Band Analysis" program.

The Northern Cheyenne Reservation in southeastern Montana occupies portions of Rosebud and Big Horn Counties and extends from the Tongue River on the east to the Crow Reservation on the west. The dominant topographic feature is the divide running from southwest to northeast between the Tongue River and Rosebud Creek. Numerous subsidiary drainages lead into these waterways. Slopes are generally moderate with some steep slopes which are short in length. Elevation varies from 2900 to 4700 feet. The majority of the timber is found in the higher elevations.

The usually gentle topography provides for easy logging, good accessibility and low cost road construction. The area is well roaded already with ranch roads and fire trails near most major ridges and creek bottoms. The steeper country can be logged during the summer months and the ridgetops and plateaus in the winter months. Rubber tired skidders can be utilized in nearly all areas.

The forest soils in general are of medium texture, are relatively uniform, and are derived from shales and sandstones of the Tongue River member of the Fort Union formation. The soils in which Ponderosa Pine grows vary from deep loam and fine sandy loam soils on gentle fans and footslopes to fragmental soils that have more than 90 percent coarse fragments below depths of 10 inches on moderate to steep slopes.

The climate is semi-arid. Average annual precipitation at Lame Deer (elevation 3331 feet) is 16.73 inches and somewhat more in the higher timbered areas. Records show that about 60 percent of the average annual precipitation falls on the reservation area during the period from March to July which includes the early growing season.

The land ownership on the reservation is mixed, with trust and fee patent

[illegible] is divided into allotted and Tribal land. Only one percent of the forested land on the reservation is fee patent however and of the trust land that is forested, 15 percent is allotted. Provided that the owners on an allotment wish to sell their timber the allotted timber will be included in timber sales along with the Tribal timber.

Logging operations began on the reservation in the 1870's or 1880's with the coming of the railroad into this area and have continued in varying degrees to the present. Observation of sites where timber has been harvested during the past century shows that favorable moisture patterns and good revegetation have prevented accelerated soil erosion. In some of the past timber sale areas, control over operators was lacking, yet the operators' nonawareness of possible consequences apparently did not have negative results. Nearly 50,000 acres have been cut over on the reservation during the [illegible].

I. Timber Description

The Northern Cheyenne forest is divided into a large, dense stand in the north central section of the reservation, and scattered stands in the west and southwest. Forested areas are primarily found on north facing slopes, and moist creek bottoms. The stands are pure ponderosa pine which is the climax type. Limited precipitation and physical isolation have apparently prevented the establishment of other commercial species. The forest has been subjected to many fires as is evident by the fire scares on the trees and the dense even-aged stands of reproduction. This fire history along with the "high grading" of railroad ties and other products utilizing the intermediate trees in the forests in the late 1800's and early 1900's has resulted in a forest composition of largely overmature and sapling trees.

Other stands are uneven aged with a fair complement of all age classes. Primarily as a result of fire control, the trend of the forest has been to expand into the grasslands in and around the forest and an increase in stocking in areas where previously the stand was sparse. This expansion trend is expected to continue.

Site quality varies considerably throughout the forest. Site indexes (100 year base) in the 80's and 90's occur commonly in the creek bottoms and on the more favorable slopes while steeper south slopes and poorer soil conditions are reflected by site indexes as low as the 30's and 40's. True site indexes are difficult to obtain in areas of dense reproduction and saplings because competition is so keen that true site trees, free from the affects of competition are rare. Mature and overmature trees in these areas show very little growth. Thrift of the trees varies generally by age classes. Mature and overmature trees are not usually thrifty because of the slow growth and occurence of disease due to age and to overcrowding by the understory. Young sawtimber, poles, saplings and seedlings are generally thrifty except where competition from overstocking has caused a reduction in growth. Both local experience and the literature indicate that the overstocked stands are ripe for major pest infestations.

Timber quality, as indicated by results of a log grade study performed in 1969, is of comparitively low quality, but marketable by present standards. Expectations are high that the present forest development program, and declining supply of high quality timber elsewhere, will greatly increase both the quality and merchantability of this resource.

II. Timber Inventory

A very thorough, two phase inventory of the timber on the reservation

[illegible] type maps were made of the forests primarily from 1/24,000 scale color photos augmented by other aerial photography. The timber stands were typed by height, density, tree problems and cut classification. This inventory provided accurate acreage computations for the total forest and for the individual types. Of this acreage, 1,970 acres are fee patent land 129,800 acres are trust land. A portion of the trust acreage, approximately 10 to 15 percent, does not contain commercial forests due to low densities, steep slopes, etc.

III. Silvicultural Method

The Northern Cheyenne forest is an all-aged forest, ranging in age from the seedlings to overmature trees older than 250 years. Trees of different ages occur singularly and in groups. Mature and overmature stands characteristically are open with a dense understory of saplings and poles.

The forest is to be selectively harvested in accordance with Northern Cheyenne Marking Rules. Harvest objectives are to remove high risk, damaged, diseased, suppressed and overmature trees, and to place particular emphasis on optimizing growing space for the residual stand. Variations from the individual tree selection method, such as group selection, or variations of seed tree/shelterwood systems may be substituted where stand conditions dictate in order to accomplish the aforementioned harvest objectives. Under no circumstances will these optional silvicultural methods be utilized where adequate seedbed preparation cannot be accomplished.

Slash treatment will be by lopping and scattering except on the landings and along the logging roads where the slash will be machine piled and burned. In general, the south and southwest slopes do not warrant much slash treatment

because of the light stocking. The north, northeast slopes are heavily stocked but where follow-up thinning projects are planned for these areas any piling of logging slash would be wasted effort, for the thinning slash will be laid down in the same areas. Such areas will be lopped and/or trampled within one year after thinning.

Abundant seedcrops are common in this area and normally regeneration after logging other than the south and southwest slopes is not a problem. Ordinarily the normal disturbance caused by logging will provide ample preparation of seedbed. However, where needed, special seedbed prepartion projects will be instituted provided funds are available. Planting where needed to fill in understocked holes in residual stands will also be accomplished.

IV. Water Quality Protection

General guidelines have been developed to avoid (or minimize) soil and water quality changes resulting from timber harvest. Steps will be taken to prevent interruption of water flow (surface and subsurface), increases in stream sediment loads, and mass movement of soil, which can result from timber harvest. No chemical changes to the water resource is anticipated, and chemical change to the forest soils will be limited to the temporary change in amounts of organic matter present.

The process of selectively cutting trees requires that motorized skidding vehicles cover much ground surface in hauling the logs to collection points for loading. This results in very little concentrated disturbance to the forest floor. Where concentrated activity is anticipated, construction of "skid trails" will be surpervised by the Forest Manager to provide the best possible protection for the soil, and water movement pathways.

[illegible] by the Northern Cheyenne Agency Foresters. During all phases of construction and harvest, inspections will be made to insure compliance with [illegible]. Locally applicable guidelines have been formulated that will minimize the extent of surface disturbance by [illegible]. Road surface and [illegible] the harvest. However, gradient standards for forest roads will not be relaxed to minimize road [illegible] except where required to insure road stability, road surfacing will [illegible] soil to facilitate reclamation. All road crossings of live or intermittent streams will require the placement of permanent or temporary culverts [illegible].

[illegible]xcept where it is determined that a permanent road is necessary for [illegible] protection, etc., all newly constructed roads will be temporary. At the completion of timber harvest and related activities, all temporary roads and skid trials will be made impassable by removal of culverts, and by other appropriate means. All road closures will include construction of water bars and other water dispersion structures as necessary to promote percolation of [illegible] rather than surface flow. Contingency plans call for broadcast seeding of [illegible] grasses after road closure, however local experience has shown that in most cases removal of traffic is all the action required to insure rapid re-establishment of native vegetation. Logging disturbance on this forest [illegible] rapid revegetation.

Only limited activity will be allowed in areas of unstable soil conditions, or in any valley bottom where surface flow of water occurs at anytime during the year. Harvest of certain sites on the reservation is being postponed due to steep or unstable slopes which cannot be logged at present without risk of at least temporary increases in local stream sediment loads.

Normal logging activity will be halted during the three to four week spring break-up when surface runoff is highest, and risk of direct sedimentation is greatest. In all phases of harvest and construction, machinery will only be allowed in water courses during the preparations of suitable crossings.

V. Additional

The primary use of this woodland, other than forest management is for livestock grazing, and this deserves special consideration in some instances. Range operators have indicated that clogged log culverts not removed after previous logging operations now provide additional watering sites for livestock. With this aspect of multiple-use to consider, some crossings of intermittent minor streams may be constructed without a culvert. This would be done only at the specific instructions of the Sale Unit Officer, and in instances where soil is present with suitable characteristics for impoundments. These structures would not be removed as part of closing a road.

[illegible]

1. [illegible], Bureau of Indian Affairs. [illegible]

2. [illegible] Regulations 25, Part 141. General [illegible]

[illegible]

[illegible] the [illegible] project [illegible] the ongoing water resources studies [illegible] staff of the Northern Cheyenne Research Project (NCRP). [illegible] little if any specific water resource data existed for the reservation [illegible] the Northern Cheyenne Tribe established the NCRP. The Tribe needed [illegible] to its political jurisdiction to make assessments of its [illegible] alternatives and the impacts of coal surface mining potentially on and adjacent to the reservation. Recently, the Tribe has placed emphasis on [illegible] and utilizing its water resources and is working toward developing [illegible]

[illegible] in gathering baseline hydrologic data that [illegible] streamflow-water quality relationships. Streamflow measuring sites and water quality sampling sites are shown in [illegible] of permanently installed weirs, gaging houses, control [illegible] and cableways [illegible]own in Figure 2.

[illegible] streamflow measurements were taken by current meter at the [illegible]

a) Rosebud Creek-where it enters the reservation (RBC #2)
b) Rosebud Creek-where it leaves the reservation (RBC #1)
c) Rosebud Creek-tributaries of
d) Tongue River-where it enters the reservation (TR #2)
e) Tongue River-where it leaves the reservation (TR #1)
f) [illegible]
   2) Logging Creek (LC)

Some exceptions to monthly measurements were encountered due to bad weather or the installation of a water control structure.

Figure 2. Monthly Stream Discharge Measurement Locations

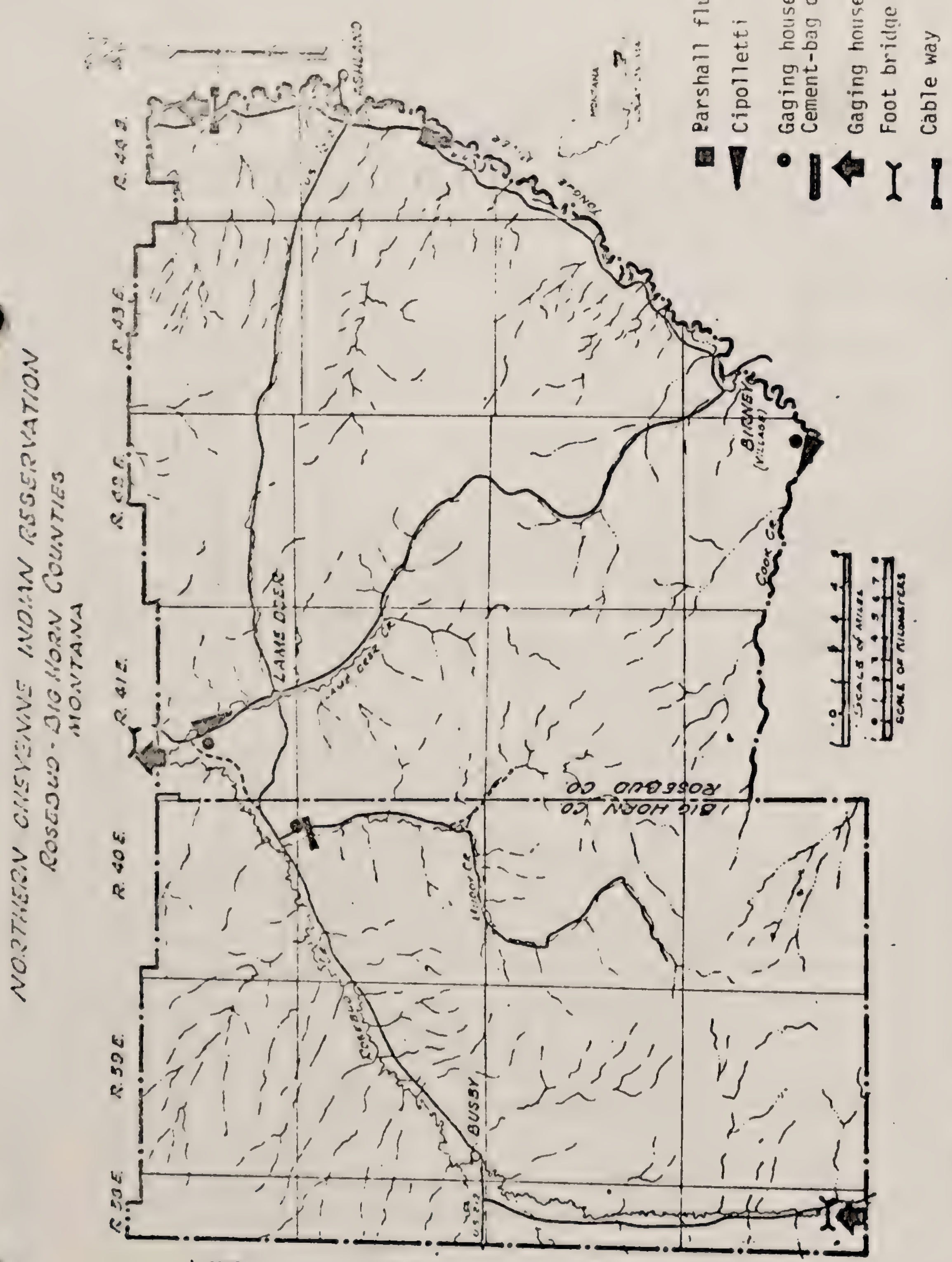


FIGURE 2 Location of weirs, gaging houses, control structures, foot bridges and cable ways contracted with Morning Star Enterprises Inc.

All discharge measurement procedures followed recommended procedures of the U.S. Geological Survey (USGS).[1,2] Gaging stations were designed from information presented in "Techniques of Water Resource Investigations",[3] manuals of the United States Geological Survey.

New preliminary stage - discharge rating curves have been prepared for TR #1, TR #2, RBC #1 and RBC #2 and are presented in Figures 3 through 6. The Tongue River stations apparently need more data points to better define the stage - discharge relationship. The curves for RBC #1 and #2 appear consistent but should be verified by additional streamflow measurements.

The apparent downward shift in the stage - discharge curve for TR #1 from 1975 to 1976 may be caused by the stage measurement arm having been bent downward. The cause and extent of this problem is being evaluated. It is possible that new stage measurement devices may need to be installed. Another possible explanation is that not enough stage - discharge measurements have yet been taken to accurately define the proper relationship. Once strip charts of continuous stage levels are analyzed it will be possible to determine whether discharge measurements were taken on the rising or falling limb of the hydrograph.

FIGURE 3

DISCHARGE RATING CURVE FOR NCRP STATION
TONGUE RIVER #1

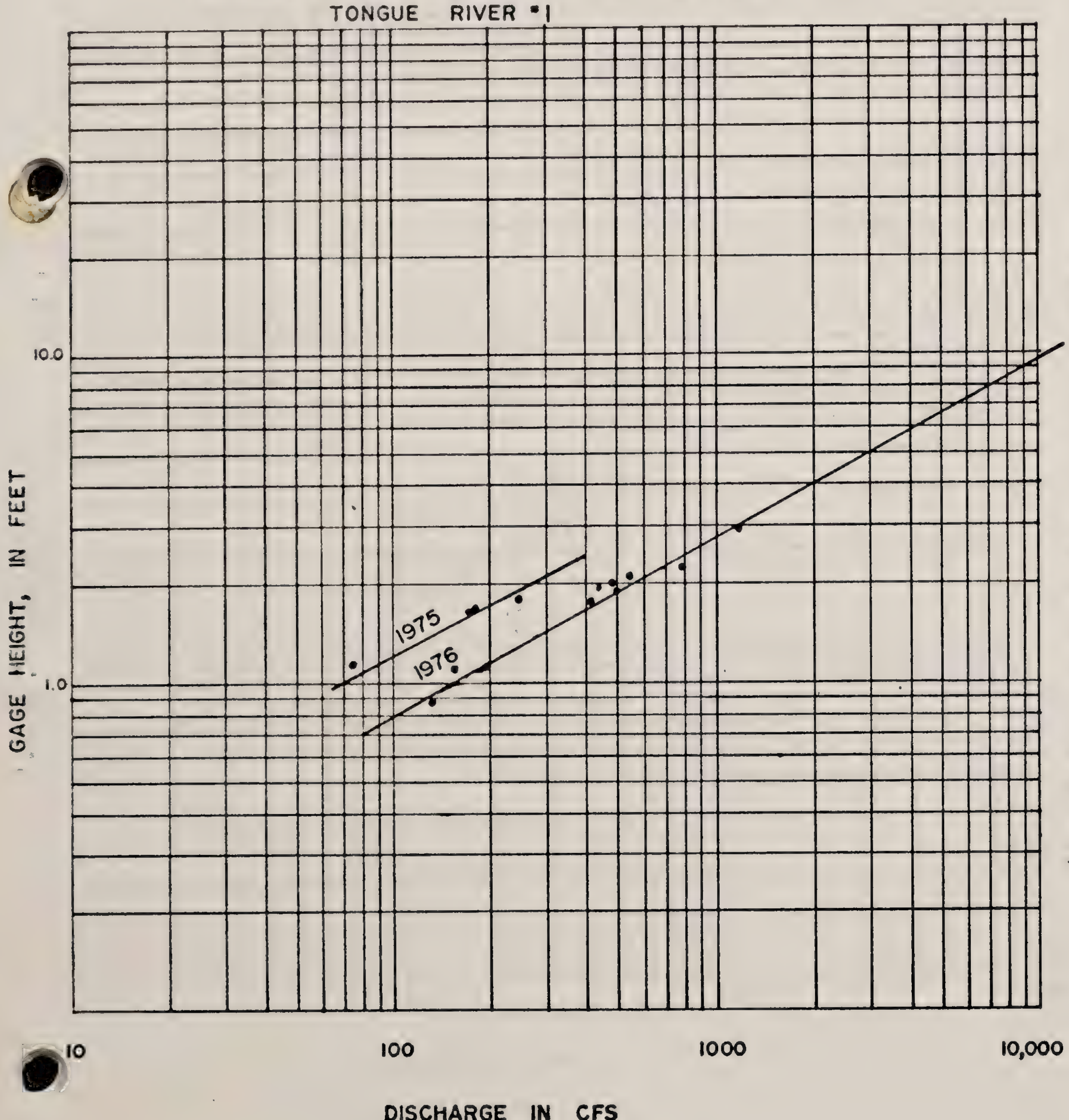


FIGURE 4

DISCHARGE RATING CURVE FOR NCRP STATION
TONGUE RIVER #2

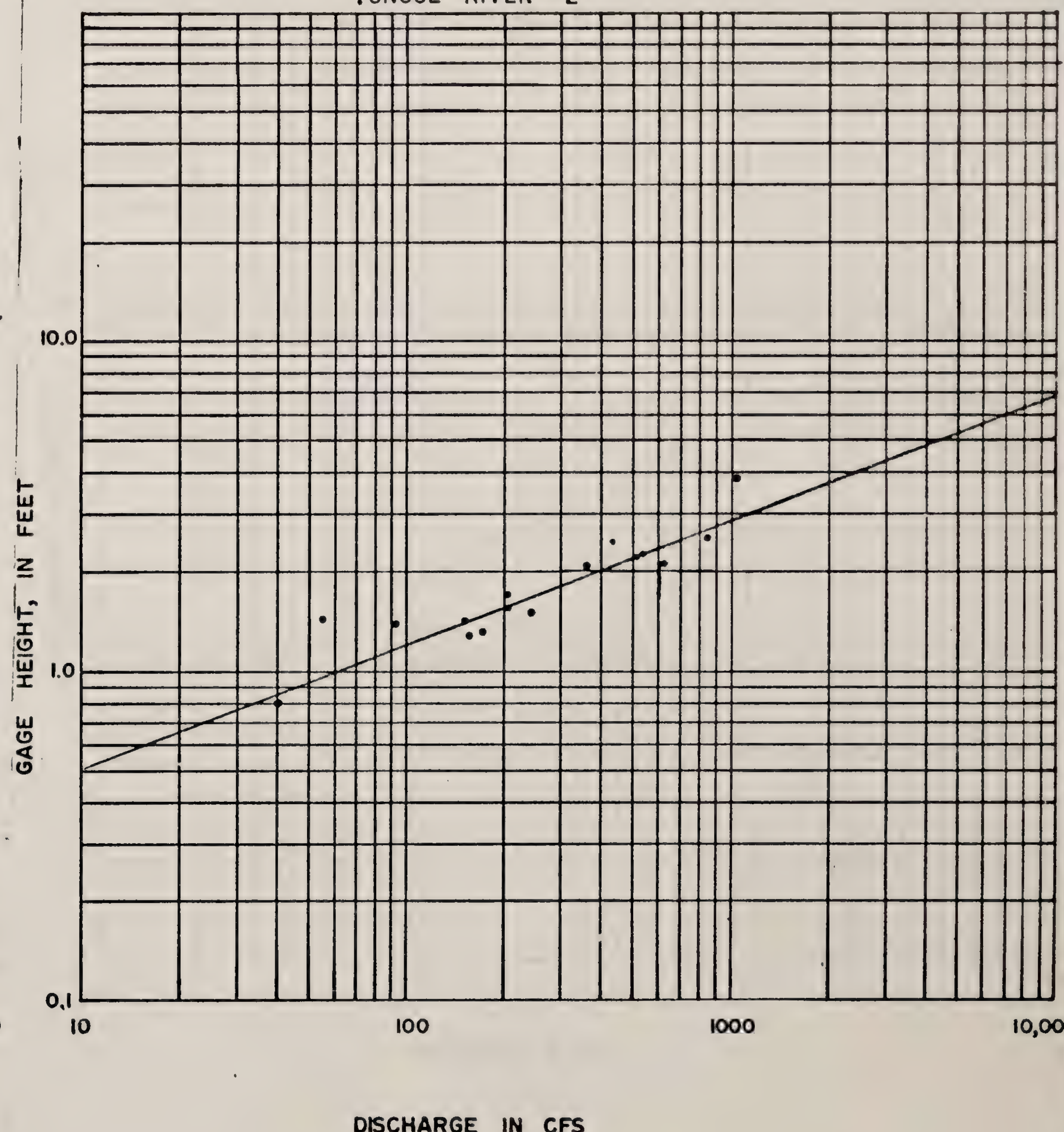
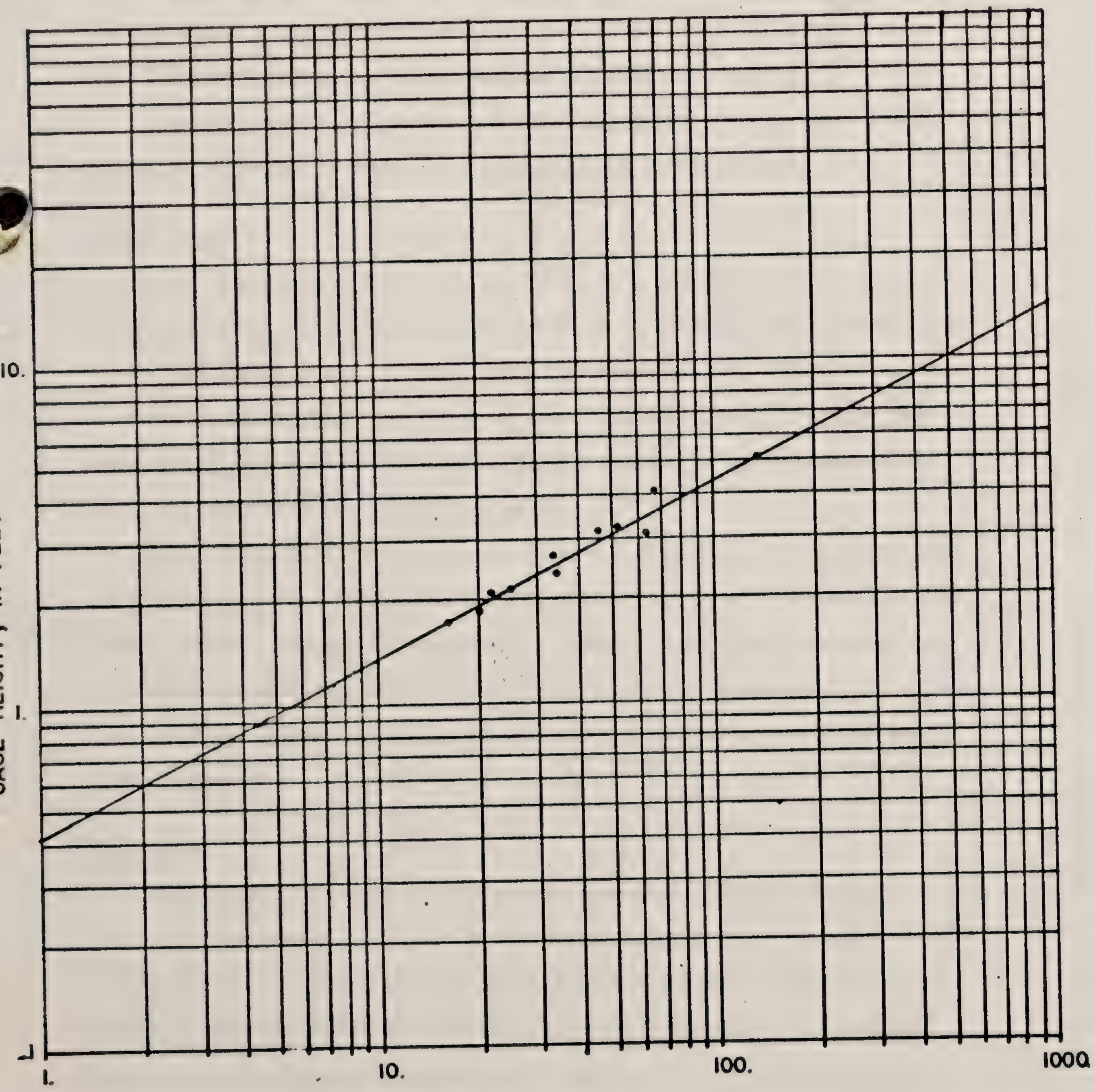


FIGURE 5

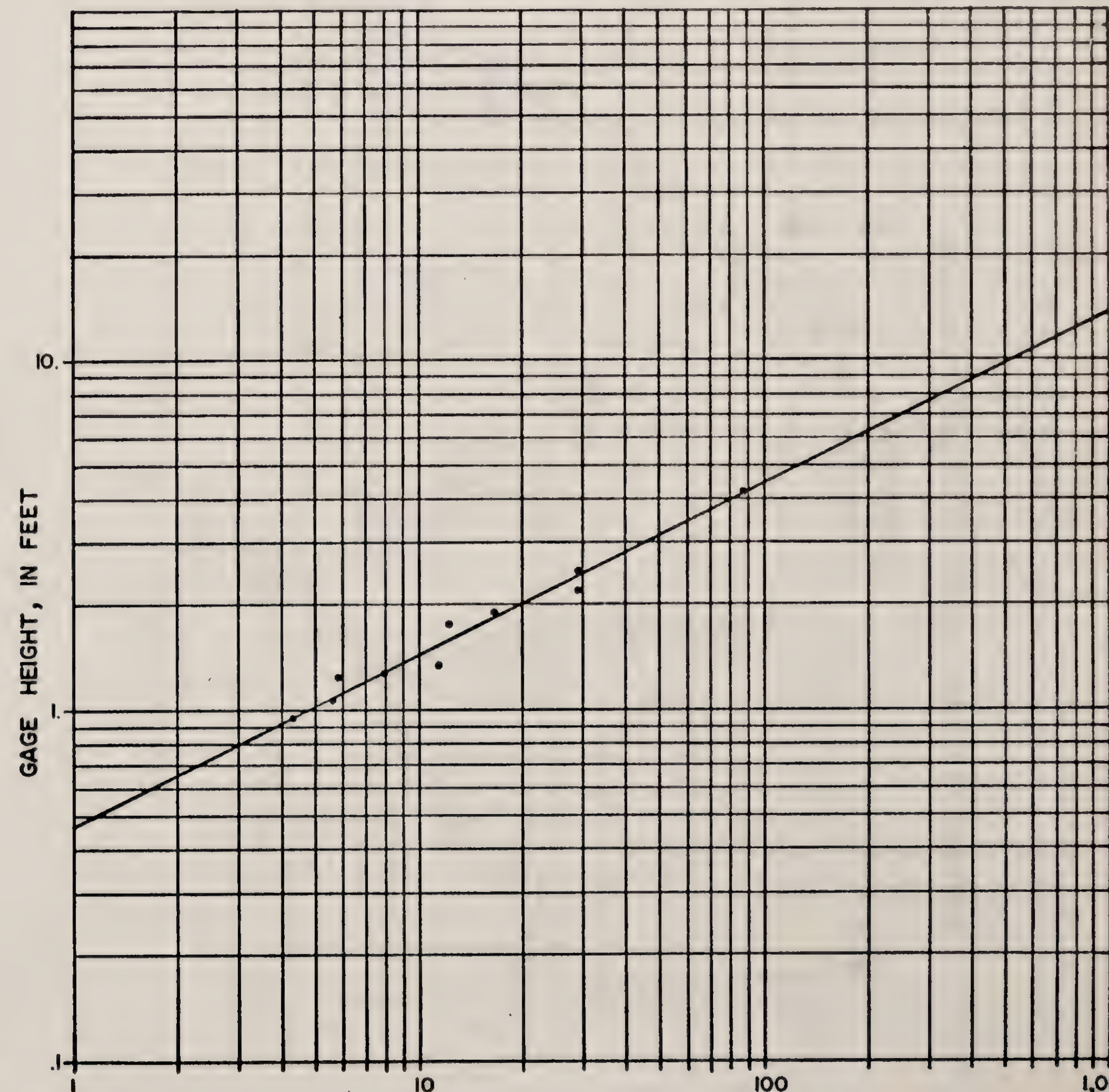
PRELIMINARY DISCHARGE RATING CURVE FOR NCRP STATION ROSEBUD CREEK "1, NEAR LAME DEER, MONTANA



E-7

FIGURE 6

PRELIMINARY DISCHARGE RATING CURVE FOR NCRP STATION ROSEBUD CREEK "2, NEAR KIRBY, MONTANA



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SURFACE WATER QUALITY MONITORING

All monthly surface water sampling sites are shown in Figure 7. Water quality sampling and stream gaging were usually performed at the same sites. All NCRP ground water monitoring stations are shown in Figure 8.

A summary over a one-year period of water quality data for each stream tested is presented in Table 1.[4] A discussion by stream follows:

Tongue River

Water quality data for the Tongue River is presented in Tables 2 and 3. Water sampled at the upstream station TR #2 is of slightly better quality than at the downstream TR #1. In most cases, the measured total dissolved solids (TDS) increased by less than 100 ppm. Data from July through November 1976 shows little difference in the TDS. The two sampling stations are separated by 79.4 river kilometers (49.6 river miles).

When streamflow data presented in Figure 7 are compared with water chemistry data, periods of high flow in June and July match up with improved water quality at both stations as expected. In both 1975 and 1976, dissolved constituent concentrations were highest during the winter months at both stations. This increase in chemical concentrations probably reflects groundwater base flow chemistry.

Cook Creek

Water quality data for Cook Creek are presented in Table 4. Water sampled at Cook Creek was lowest in TDS during July, 1976 and January, 1977. In both cases the general water quality of Cook Creek was at least two times higher in TDS than the water sampled at the nearby upstream TR #2 station. Among other constituents Cook Creek water contains 1.0 - 1.5 ppm fluoride,

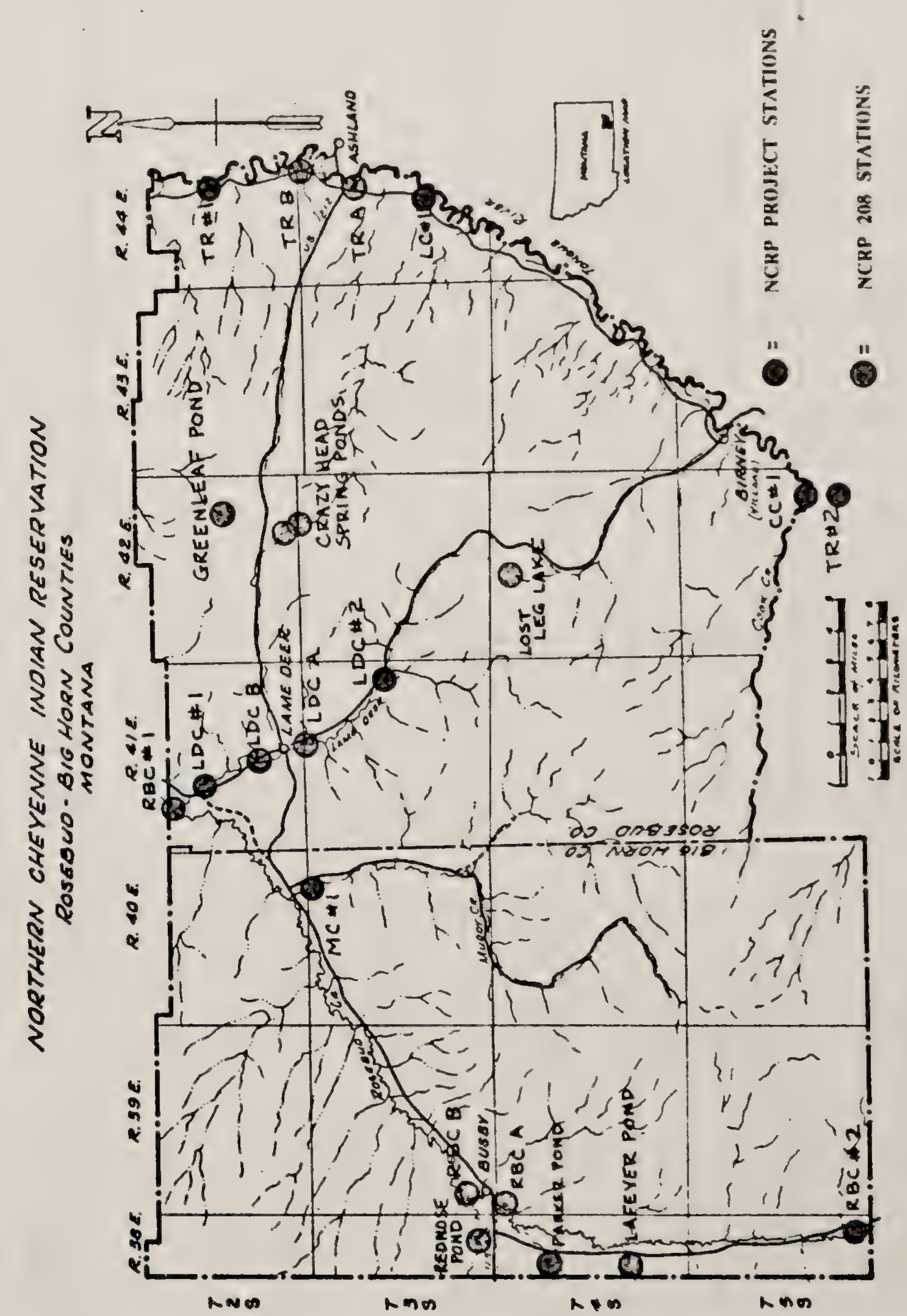

FIGURE 7. **Monthly Surface Water Sampling Locations**

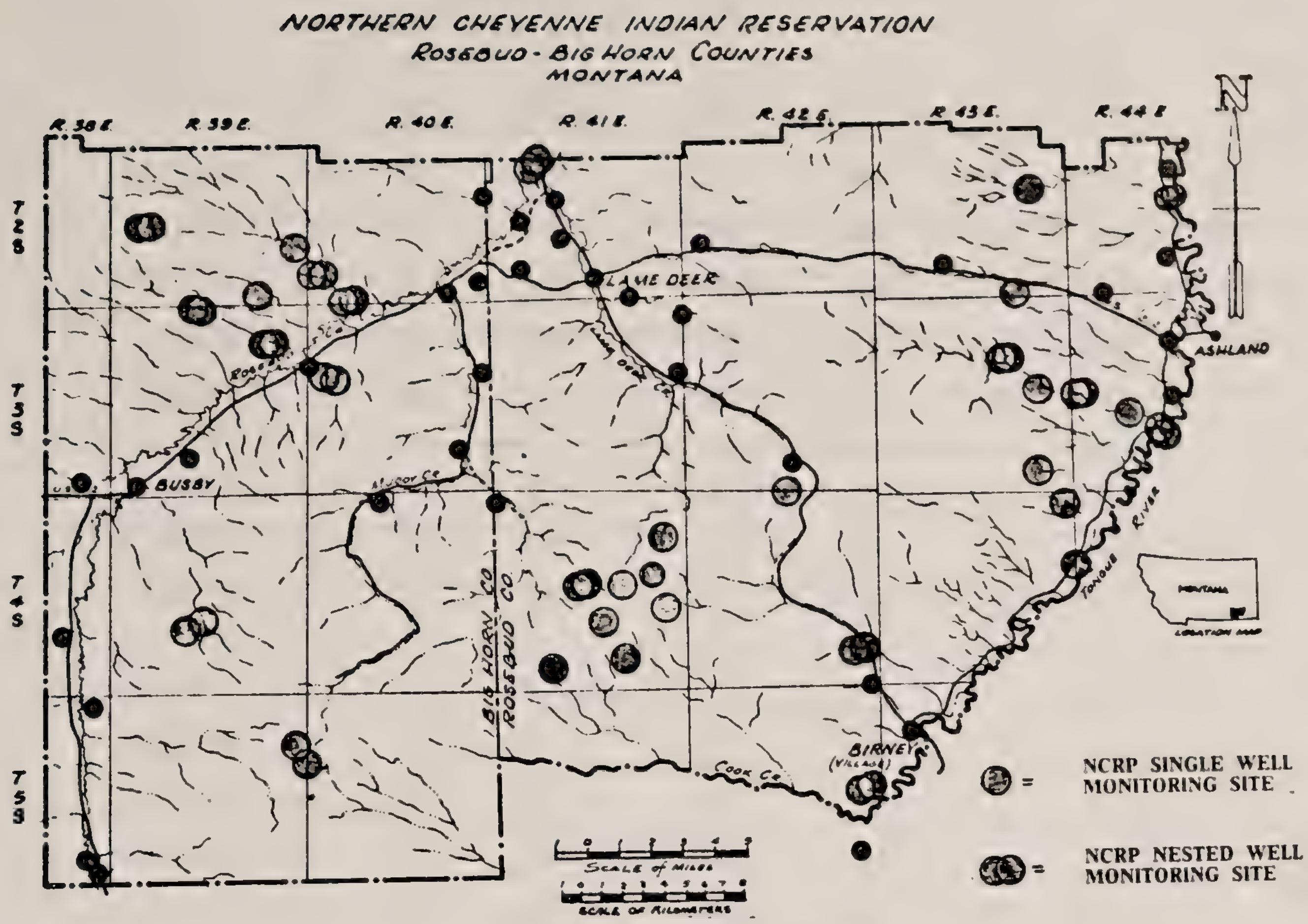

FIGURE 8 **Groundwater Monitoring Stations**

TABLE 1: SUMMARY OF TDS AND pH VALUES AT SURFACE WATER MONITORING STATIONS, 12/75 - 1/77

STATION	TOTAL DISSOLVED SOLIDS at 180'C			FIELD pH		
	NUMBER OF SAMPLES	RANGE PPM	MEAN PPM	NUMBER OF SAMPLES	RANGE	MEAN
Tongue River						
TR#1	13	264-754	557	13	6.1-9.4	7.6
TR#2	13	244-674	515	12	5.8-9.6	7.6
Cook Creek						
CC#1	13	1222-1406	1288	12	6.7-8.2	7.6
Logging Creek						
LC#1	12	454-911	659	11	6.2-8.3	7.4
Rosebud Creek						
RBC#1	15	675-875	798	15	6.8-9.5	7.9
RBC#2	15	489-636	563	15	6.6-9.1	7.8
Lame Deer Creek						
LDC#1	14	602-888	724	14	6.1-9.4	7.6
LDC#2	14	541-791	630	14	6.0-8 5	7.3
Muddy Creek						
MC#1	13	820-1235	1012	13	6.3-9.1	7.5

TONGUE RIVER # 1

TABLE #2: SURFACE WATER QUALITY REPORT

Station Number	Location	Date Sampled	Na PPM	SO_4 PPM	T. Hard. as $CaCO_3$	TDS at 180'C	Cond. Umhos.	F PPM	Fe PPM	pH	Instantaneous Discharge cfs
TR#1	SE¼ NW¼ Sec.22, T3S R44E	12/05/75	73	315	440	754	1000	0.7	<0.1	6.1	
" "	" "	1/23/76	56	286	425	652	1000	0.4	.02	6.2	
" "	" "	3/1/76	68	287	427	692	1000	0.4	.03	6.0	
" "	" "	3/17/76	67	294	434	737	1000	0.5	<.01	7.0	380
" "	" "	4/21/76	59	286	414	652	975	0.4	.02		270
" "	" "	5/27/76	42	211	332	527	750	0.3	.03	7.3	650
" "	" "	7/6/76	21	81	168	282	400	0.2	.43	7.5	
" "	" "	7/27/76	24	85	193	264	450	0.2	<.01	8.8	900
											460
" "	" "	9/2/76	32	136	249	375	500	0.3	.02	9.4	410
" "	" "	10/20/76	44	187	323	481	720	0.3	.03	8.0	225
" "	" "	11/18/76	43	187	322	480	720	0.3	0.02	7.9	330
" "	" "	12/20/76	53	271	411	681	1000	0.4	.03	8.2	196
" "	" "	1/29/77	50	235	412	666	920	0.4	<0.01	8.0	206

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TONGUE RIVER #2

TABLE #3: SURFACE WATER QUALITY REPORT

	Location	Date Sampled	Na PPM	SO_4 PPM	T. Hard. as $CaCO_3$	TDS at 180'C	Cond. Umhos.	F PPM	Fe PPM	pH	Instantaneous Discharge cfs
TR#2	SW¼ NE¼ Sec.35, T5S R43E	12/05-75	47	252	392	608	775	0.5	0.1	5.8	280
" "	" "	1/23/76	50	253	415	634	910	0.3	.03	7.0	190
" "	" "	3/1/76	57	270	427	671	970	0.3	.01	6.3	
" "	" "	3/17/76	60	269	427	674	1000	0.5	.01	7.8	200
" "	" "	4/2/76	53	244	373	598	900	0.3	.09	*	175
" "	" "	5/27/76	39	180	306	488	700	0.3	.03	7.4	205
" "	" "	7/6/76	15	50	153	220	400	0.2	.11	7.8	660
" "	" "	7/27/76	20	69	169	244	400	0.2	.04	8.8	670
											520
" "	" "	9/2/76	32	145	244	384	470	0.3	.02	9.6	360
" "	" "	10/20/76	40	185	313	470	660	0.3	<0.01	7.1	275
" "	" "	11/18/76	43	193	342	507	700	0.3	<0.01	7.5	190
" "	" "	12/21/76	45	237	367	619	900	0.4	0.03	8.2	160
" "	" "	1/20/77	40	198	392	583	900	0.3	.08	8.0	205

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COOK CREEK #1

TABLE #4: SURFACE WATER QUALITY REPORT

Station Number	Location	Date Sampled	Na PPM	SO_4 PPM	T. Hard. as $CaCO_3$	TDS at 180'C	Cond. Umhos.	F PPM	Fe PPM	pH
CC#1	NE¼ NW¼ Sec.25, T5S R42E	12/05/75	180	578	694	1338	1639	1.3	<0.1	6.7
" "	" "	1/23/76	191	530	659	1319	1750	1.2	.05	7.2
" "	" "	3/1/76	188	505	649	1226	1750	1.2	.03	6.9
" "	" "	3/17/76	179	453	612	1222	1700	1.2	.01	8.1
" "	" "	4/21/76	180	500	610	1236	1750	1.1	0.4	*
27 " "	" "	5/27/76	197	516	649	1306	1800	1.2	.01	7.1
" "	" "	7/6/76	197	498	638	1255	2000	1.0	.03	6.7
" "	" "	7/27/76	194	505	651	1288	1800	1.1	.07	7.9
" "	" "	9/2/76	200	548	691	1406	1700	1.5	.04	8.2
" "	" "	10/20/76	200	579	677	1309	1650	1.1	.06	7.7
" "	" "	11/18/76	188	506	645	1254	1700	1.0	.05	7.9
" "	" "	12/21/76	180	534	669	1319	1900	1.1	.10	8.1
" "	" "	1/20/77	210	508	629	1273	1640	1.1	.08	8.2

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LOGGING CREEK #1

TABLE #5: SURFACE WATER QUALITY REPORT

Station Number	Location	Date Sampled	Na PPM	SO_4 PPM	T. Hard. as $CaCO_3$	TDS at 180'C	Cond. Umhos.	F PPM	Fe PPM	pH
LC#1	NE¼ SE¼ Sec.21, T3S R44E	12/4/75	73	162	449	698	980	1.2	<0.1	6.5
" "	" "	1/23/76	58	129	389	576	900	1.0	.05	6.2
" "	" "	3/2/76	60	126	387	598	800	1.0	.05	6.4
" "	" "	3/17/76	67	130	401	599	950	1.1	.10	7.9
" "	" "	4/21/76	79	171	422	683	1050	1.1	.12	*
" "	" "	6/2/76	52	101	310	454	850	0.5	.54	6.8
28 " "	" "	7/6/76	61	132	391	597	800	0.9	.07	7.2
" "	" "	7/27/76	62	102	376	564	900	1.0	.09	7.9
" "	" "	10/20/76	92	185	501	801	1080	1.0	.07	8.1
" "	" "	11/18/76	76	153	432	657	1000	1.0	.01	8.1
" "	" "	12/21/76	105	277	569	911	1380	1.2	.03	8.3
" "	" "	1/20/77	63	200	486	772	1100	1.1	.16	8.1

ROSEBUD CREEK #1

TABLE #6: SURFACE WATER QUALITY REPORT

Station Number	Location	Date Sampled	Na PPM	SO_4 PPM	T. Hard. as $CaCO_3$	TDS at 180'C	Cond. Umhos.	F PPM	Fe PPM	pH	Instantaneous Discharge
RBC#1	SW¼ SW¼ Sec.8, T1S R41E	12/18/75	55	242	575	824	1020	0.6	.01	6.8	
" "	" "	1/29/76	69	277	585	840	1200	0.6	.03	6.8	
" "	" "	3/4/76	60	248	578	804	1000	0.6	.01	6.9	
" "	" "	3/30/76	52	274	521	859	1100	0.6	.04	7.9	
" "	" "	5/04/76	44	212	514	705	1100	0.6	.02	7.3	60
" "	" "	5/26/76	55	240	534	736	1000	0.6	<.01	7.7	49
" "	" "	7/8/76	50	200	473	675	1000	0.2	.04	8.1	41
" "	" "	7/28/76	59	230	482	703	1000	0.6	.07	7.4	24
" "	" "	8/6/76	67	271	492	752	1200	0.5	.03	9.5	20
" "	" "	9/1/76	79	330	537	843	1100	0.7	0.04	9.3	14.5
" "	" "	9/23/76	70	278	557	883	850	0.6	<0.01	8.2	16
" "	" "	10/21/76	67	264	567	780	1200	0.5	<0.01	8.1	23
" "	" "	11/17/76	68	289	578	875	1240	0.6	.01	7.9	25
" "	" "	12/13/76	65	276	602	875	1140	0.5	0.03	8.3	24
" "	" "	1/18/77	65	253	540	821	1230	0.7	.19	8.1	24

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ROSEBUD CREEK #2

TABLE # 7: SURFACE WATER QUALITY REPORT

Station Number	Location	Date Sampled	Na PPM	SO_4 PPM	T. Hard. as $CaCO_3$	TDS at 180'C	Cond. Umhos.	F PPM	Fe PPM	pH	Instantaneous Discharge cfs
RBC#2	NE¼ SW¼ Sec.36,T5S R39E	12/18/75	28	133	489	570	833	0.6	.01	6.6	
" "	" "	1/29/76	30	133	486	595	800	0.5	.01	6.8	
" "	" "	3/4/76	29	163	541	636	890	0.7	.05	8.3	
" "	" "	3/30/76	21	157	452	556	750	0.5	<.01	7.9	
" "	" "	5/04/76	18	132	432	531	750	0.5	.02	7.6	36
" "	" "	5/26/76	22	123	439	573	750	0.6	.05	7.7	21
" "	" "	6/23/76	25	376	376	526	800	0.5	<.01	8.0	24
" "	" "	7/8/76	25	122	408	534	1000	0.6	.41	8.2	12
" "	" "	7/28/76	29	102	405	528	750	0.6	<.01	7.0	7.2
" "	" "	9/2/76	40	123	455	581	900	0.7	.03	9.1	3.7
" " "	" "	9/23/76	40	141	481	604	700	0.6	.32	8.4	3.9
" "	" "	10/21/76	38	126	462	550	960	0.6	.03	7.3	7.8
" "	" "	11/17/76	35	140	491	605	940	0.6	<.01	7.9	8.5
" "	" "	12/13/76	27	115	468	577	860	0.4	.03	8.2	6.3
" "	" "	1/18/77	29	116	476	489	900	0.7	0.06	8.2	6.1

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LAME DEER CREEK #1

TABLE #8: SURFACE WATER QUALITY REPORT

Station Number	Location	Date Sampled	Na PPM	SO_4 PPM	T. Hard. as $CaCO_3$	TDS at 180'C	Cond. Umhos.	F PPM	Fe PPM	pH
LDC#1	NW¼ SE¼ Sec.17, T2S R41E	12/11/75	69	194	496	757	1111	1.1	<0.1	6.1
" "	" "	1/22/76	76	196	470	716	1200	0.8	.02	6.4
" "	" "	3/3/76	81	206	575	841	1080	0.9	.03	7.8
" "	" "	3/25/76	41	102	423	604	1000	0.9	<.01	8.3
" "	" "	5/02/76	47	119	427	563	850	0.8	.01	6.4
" "	" "	5/25/76	48	125	417	602	800	0.7	.06	6.8
" "	" "	6/21/76	72	189	513	759	1300	0.9	<.01	7.4
" "	" "	7/29/76	69	157	472	719	1100	0.9	.05	7.2
" "	" "	9/1/76	70	179	481	733	1000	0.9	.05	9.4
" "	" "	9/21/76	71	179	507	731	1149	0.9	.08	8.8
" "	" "	10/19/76	69	188	507	791	1120	0.8	.02	8.0
" "	" "	11/15/76	79	218	583	827	1280	0.9	.06	7.3
" "	" "	12/16/76	80	204	547	888	1400	1.0	.06	8.4
"	" "	1/19/77	93	220	525	607	1240	0.8	<.01	8.3

LAME DEER CREEK #2

TABLE #9: SURFACE WATER QUALITY REPORT

Station Number	Location	Date Sampled	Na PPM	SO_4 PPM	T. Hard. as $CaCO_3$	TDS at 180'C	Cond. Umhos.	F PPM	Fe PPM	pH
LDC#2	SE¼ SW¼ Sec.13, T3S R41E	12/16/75	45	121	444	594	2128	0.9	0.1	7.6
" "	" "	1/22/76	48	114	433	541	900	0.8	.02	6.3
" "	" "	3/3/76	47	127	449	556	875	0.7	.01	6.0
" "	" "	3/25/76	70	201	465	753	1100	1.1	<.01	7.6
" "	" "	5/2/ 76	78	206	538	791	1200	1.0	.01	7.2
" "	" "	5/25/76	78	195	512	783	1200	0.9	.02	7.6
" "	" "	6/12/76	48	118	426	594	1100	0.9	.01	6.5
" "	" "	7/29/76	49	105	424	585	950	0.7	.08	6.4
" "	" "	9/1/76	55	123	471	627	900	0.8	.18	8.5
" "	" "	9/20/76	50	109	443	594	700	0.7	.04	8.0
" "	" "	10/19/76	50	119	447	599	950	0.7	<.01	7.5
" "	" "	11/15/76	50	123	448	581	980	0.7	<.01	7.3
" "	" "	12/16/76	44	118	446	597	980	0.8	.06	8.2
" "	" "	1/19/77	53	123	436	618	960	0.8	.06	7.9

MUDDY CREEK #1

TABLE #10: SURFACE WATER QUALITY REPORT

Station Number	Location	Date Sampled	Na PPM	SO_4 PPM	T. Hard. as $CaCO_3$	TDS at 180°C	Cond. Umhos.	F PPM	Fe PPM	pH
MC#1	NE¼ SE¼ Sec.2, T3S R39E	12/18/75	88	405	691	1056	1351	0.7	.01	6.8
" "	" "	1/28/76	89	393	845	1058	1500	0.8	.03	6.3
" "	" "	3/2/76	98	417	689	1049	1700	0.7	.03	7.9
	" "	3/31/76	95	398	675	958	1400	0.7	<.01	7.8
" "	" "	4/26/76	62	300	575	820	1200	0.6	.05	7.2
" "	" "	6/24/76	68	317	570	872	1200	0.5	.10	6.9
" "	" "	7/29/76	79	328	573	920	1300	0.6	.39	6.6
" "	" "	9/2/76	94	380	625	986	1250	0.7	.04	9.1
" "	" "	9/2/76	92	384	658	994	1000	0.7	<.01	8.8
" "	" "	10/26/76	91	393	697	1102	1600	0.6	.18	6.2
" "	" "	11/15/76	144	475	787	1235	1550	0.08	.05	7.1
" "	" "	12/15/76	100	402	702	1076	1400	0.7	.02	8.3
" "	" "	1/19/77	69	404	738	1031	1480	0.9	<.01	8.1

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compared to 0.2 - 0.5 ppm found in the Tongue River. Daily stage data have been collected at Cook Creek since November, 1976.

Muddy Creek

Water quality data for Muddy Creek is summarized in Table 10. Water quality is higher in dissolved chemical constituents than the waters of Rosebud or Lame Deer Creek. The large TDS measurements in winter and early spring probably represent ground water base flow discharge.

Streamflow - Water Quality Relationships

Simple frequency distributions of total dissolved solids (TDS) concentrations for stations TR #1, TR #2, RBC #1 and RBC #2 are presented in Figures 9 through 12. Comparison of TR #1 and TR #2 shows that the downstream station, TR #1, has two samples in the 700 to 900 parts per million (ppm) TDS range. This reflects a general increase in TDS in the downstream direction, probably due to increasing consumptive use, irrigation return flows and additional baseflow contribution high in TDS. This trend is evidenced even more dramatically in Rosebud Creek and Figures 11 and 12. The upstream station, RBC #2, exhibits a predominance of samples in the 500 to 600 ppm TDS range, while the more downstream RBC #1 shows a wider range of TDS with a predominance in the 700 to 900 ppm range. As suspected, measurements confirm that the highest TDS concentrations occur from late summer through the winter months, while the lowest concentrations happen exclusively in the several months during snowmelt runoff and early summer rains.

The disproportionately greater increase in TDS in the downstream direction shown by Rosebud Creek in comparison to Tongue River reflects several likely causes. The Tongue River dam stores high quality snowmelt waters for later

FIGURE 9 NUMBER OF SAMPLES HAVING TOTAL DISSOLVED SOLIDS VALUES IN THE RANGES INDICATED, NCRP STATION TONGUE RIVER #1, NEAR ASHLAND, MONTANA, DECEMBER 1975 THROUGH MAY 1977

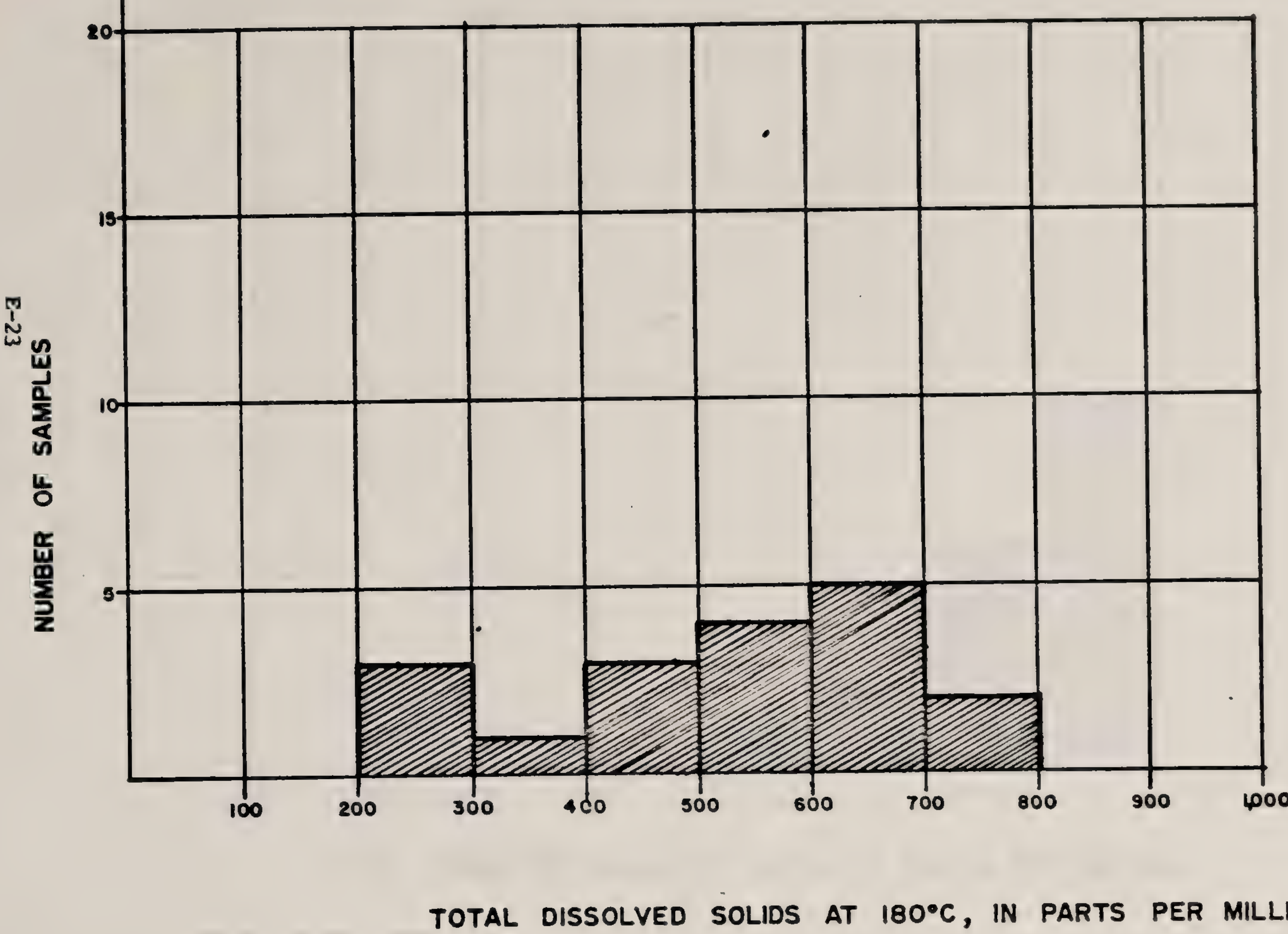

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FIGURE 10 NUMBER OF SAMPLES HAVING TOTAL DISSOLVED SOLIDS VALUES IN THE RANGES INDICATED, NCRP STATION TONGUE RIVER #2, NEAR BIRNEY, MONTANA, DECEMBER, 1975 THROUGH MAY, 1977

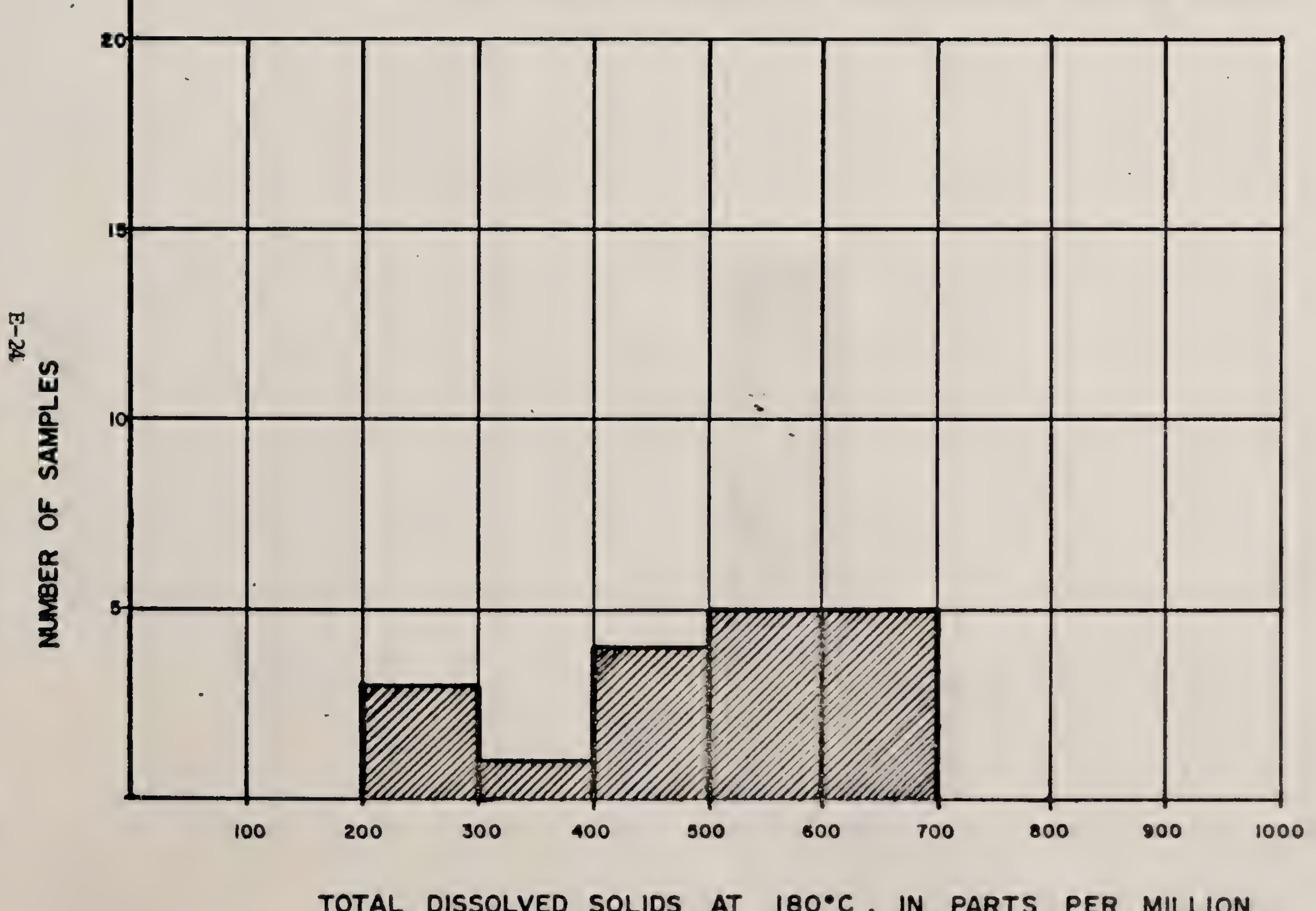

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FIGURE 11 NUMBER OF SAMPLES HAVING TOTAL DISSOLVED SOLIDS VALUES IN THE RANGES INDICATED, NCRP STATION ROSEBUD CREEK #1, NEAR LAME DEER, MONTANA, DECEMBER 1975 THROUGH MAY 1977

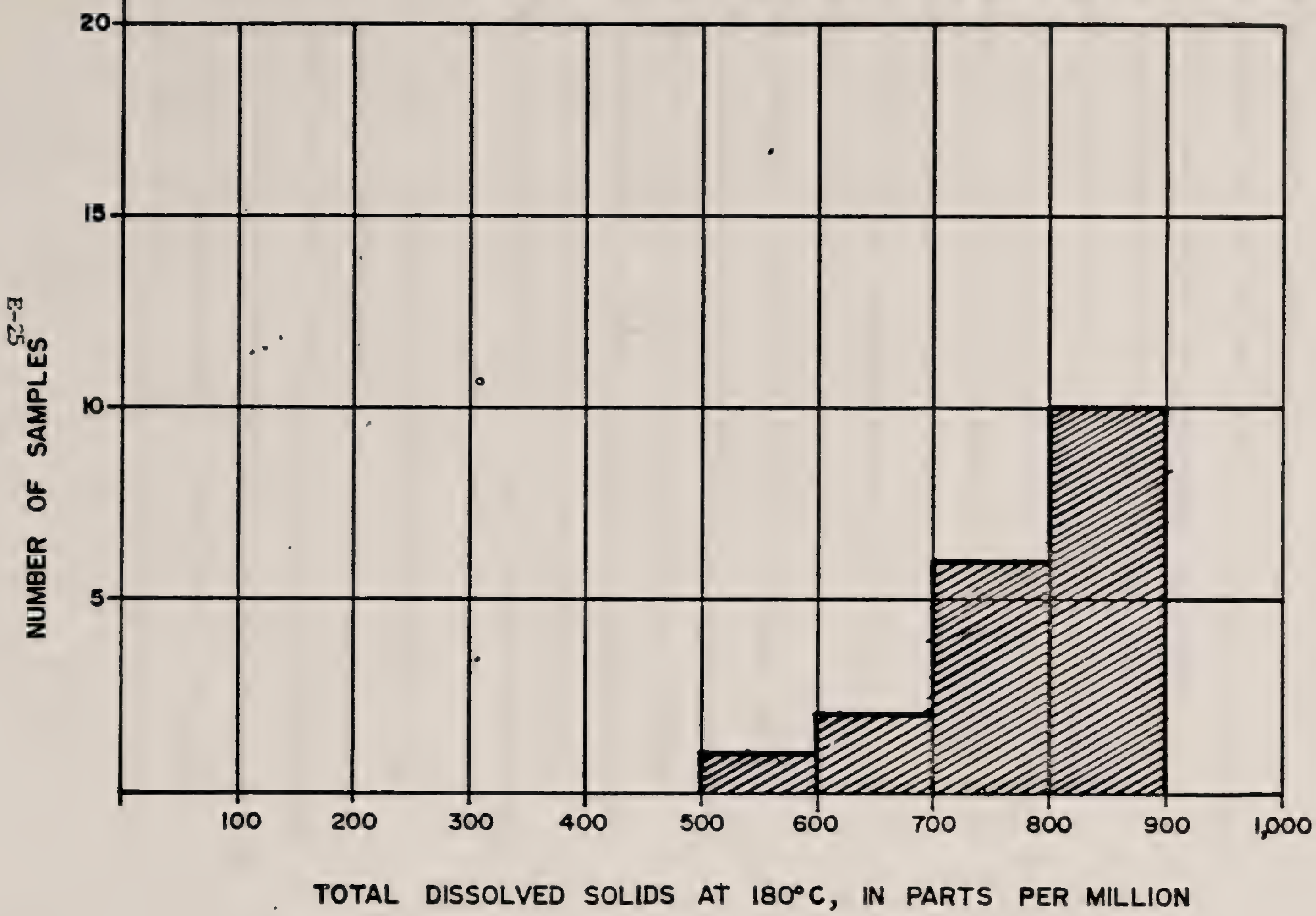

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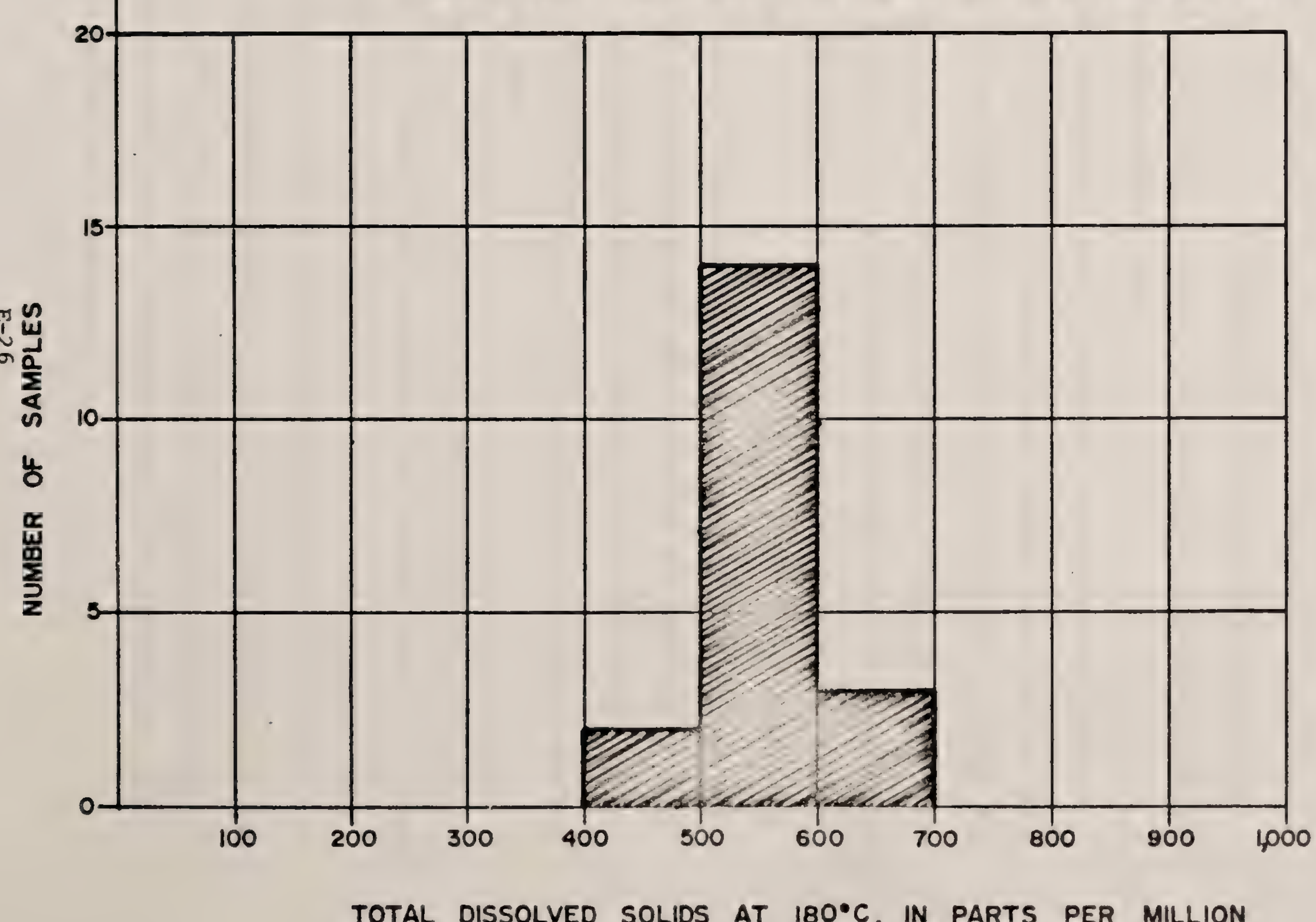
FIGURE 12 NUMBER OF SAMPLES HAVING TOTAL DISSOLVED SOLIDS VALUES IN THE RANGES INDICATED, NCRP STATION ROSEBUD CREEK #2, NEAR KIRBY, MONTANA, DECEMBER 1975 THROUGH MAY 1977



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release, whereas Rosebud Creek has no dam. The Rosebud is likely composed of a greater percentage of high TDS baseflow throughout the late summer and winter. Any consumptive uses such as irrigation or that by riparian vegetation and irrigation return flows have a proportionately greater impact on the Rosebud Creek TDS load than with the same use rate on the Tongue River. With the data collected to date, it does not appear that ground water in the alluvium of Rosebud Creek valley is higher in TDS than that in the Tongue River valley.

Season trends in TDS and streamflow are presented for Tongue River and Rosebud Creek surface waters in Figures 13 through 16. TDS values are actual laboratory results of monthly sampling and discharge values were obtained from the stage - discharge rating curves previously discussed.

In the Tongue River, both the upstream and downstream stations show the same general trend: Increasing TDS with decreasing discharge in the fall, a variable but tight pattern of high TDS and low discharge throughout winter, greatly increasing discharge and slightly decreasing TDS in spring, continual high discharge and sharply decreasing TDS in early and mid-summer, followed by sharply decreasing discharge and gradually increasing TDS throughout latter summer. When overlayed, the TR #1 and TR #2 curves coincide very closely with only the spring and early summer portions of the TR #1 curve being slightly higher in TDS.

The Rosebud Creek TDS - streamflow curves show somewhat different relationships. The shape of both RBC #1 and RBC #2 curves are longer and more constricted than Tongue River, indicating generally more constant TDS concentrations throughout the year. The RBC #2 relationship exhibits one significant difference from the other three in that the cycle of spring - early summer - late summer trends is reversed. Fall and winter give the variable but tight pattern of low

discharge - high TDS values, but then in spring with slightly increasing discharge, TDS drops sharply, remains nearly constant through the peak discharge period, and then gradually increases with sharply decreasing discharge in early summer. Late summer values correspond closely with those in fall and winter. Although more TDS and discharge measurements are needed to verify this relation, field conductivity measurments tended to substantiate the results shown.

The RBC #1 curve in Figure 15 is similar to the trends of the Tongue River stations except that the seasons appear shifted forward on the line. Spring has the peak discharge - low TDS peak on the right-hand side of the graph at RBC #1 whereas it was in early summer on Tongue River. When overlayed, the entire RBC #1 curve is above the RBC #2 curve. Also, as previously mentioned, the spring and early summer portions of the curve are reversed from RBC #2.

Developing the total dissolved solids - streamflow relationships are very important to understanding the natural systems now operating in these drainages. It is an initial key to integrating the characteristics of the ground water data and determining how the surface and ground water systems interact over time.

Instantaneous water temperatures and general temperature trends for the Tongue River and Rosebud Creek are presented in Figures 17 and 18. It should be recognized, these data are of limited usefulness because they are spot readings taken at the time discharge measurements or water samples were collected. They were taken at different times of day at various depths or locations in the stream cross-section. Especially in summer, normal diurnal variations show a wide range of fluctuation and it is more difficult to determine the average daily temperature.

FIGURE 13 SEASONAL TRENDS IN TOTAL DISSOLVED SOLIDS VS. STREAMFLOW FOR NCRP STATION TONGUE RIVER #1, MAY 1976 TO MAY 1977.

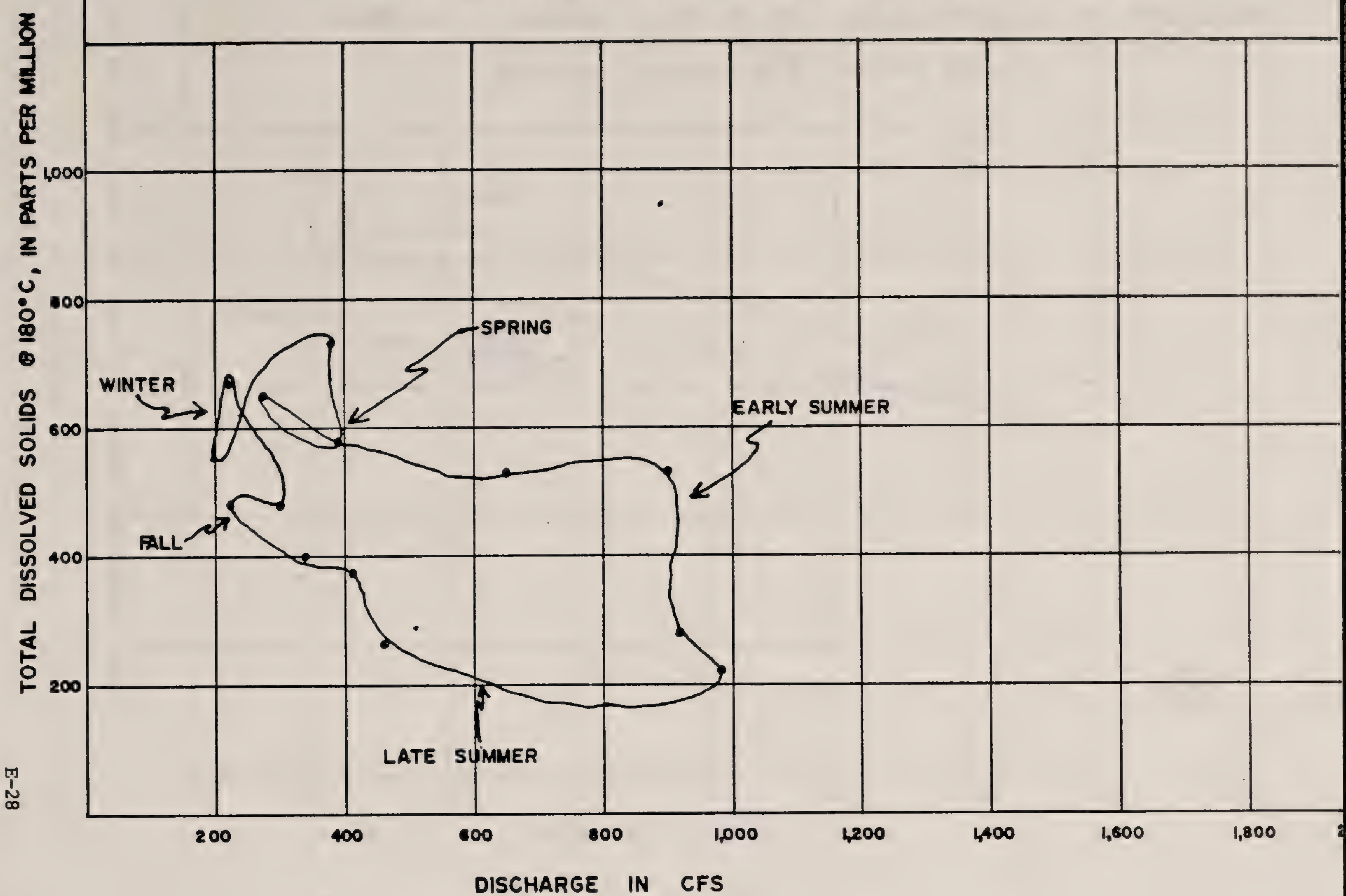
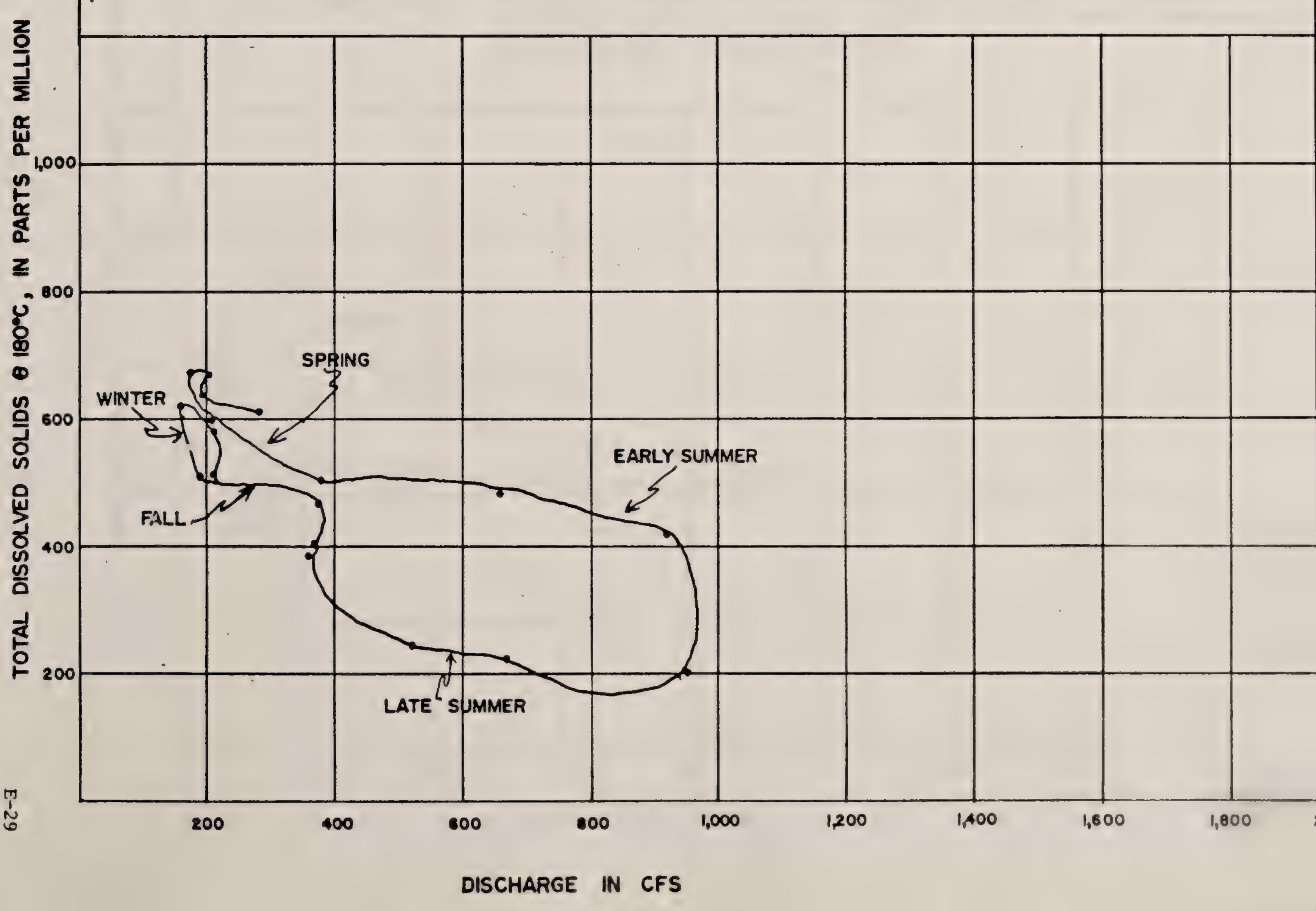


FIGURE 14 SEASONAL TRENDS IN TOTAL DISSOLVED SOLIDS VS. STREAMFLOW FOR NCRP STATION TONGUE RIVER #2, DECEMBER 1975 TO MAY 1977



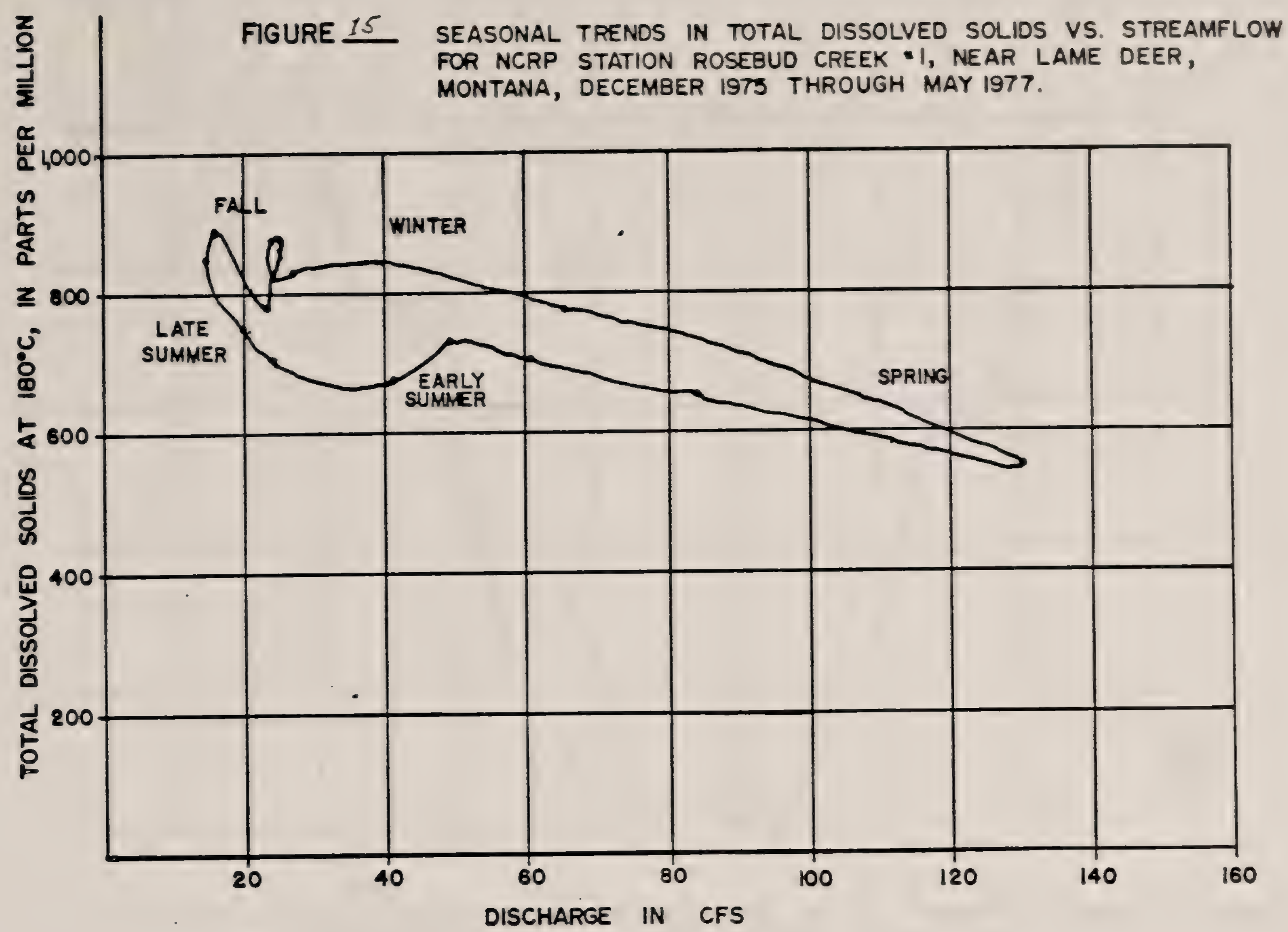


FIGURE 15 SEASONAL TRENDS IN TOTAL DISSOLVED SOLIDS VS. STREAMFLOW FOR NCRP STATION ROSEBUD CREEK #1, NEAR LAME DEER, MONTANA, DECEMBER 1975 THROUGH MAY 1977.

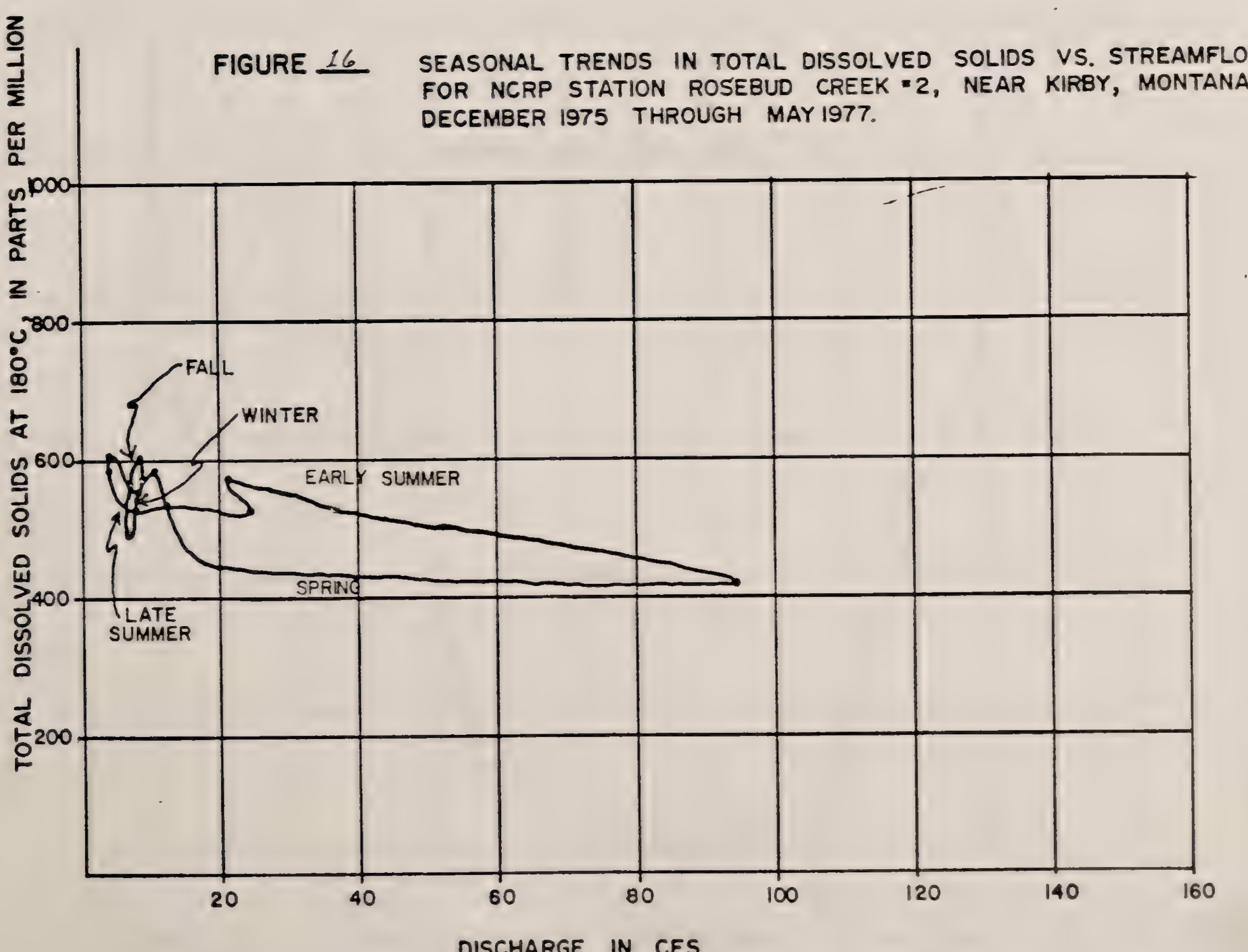


FIGURE 16 SEASONAL TRENDS IN TOTAL DISSOLVED SOLIDS VS. STREAMFLOW FOR NCRP STATION ROSEBUD CREEK #2, NEAR KIRBY, MONTANA, DECEMBER 1975 THROUGH MAY 1977.

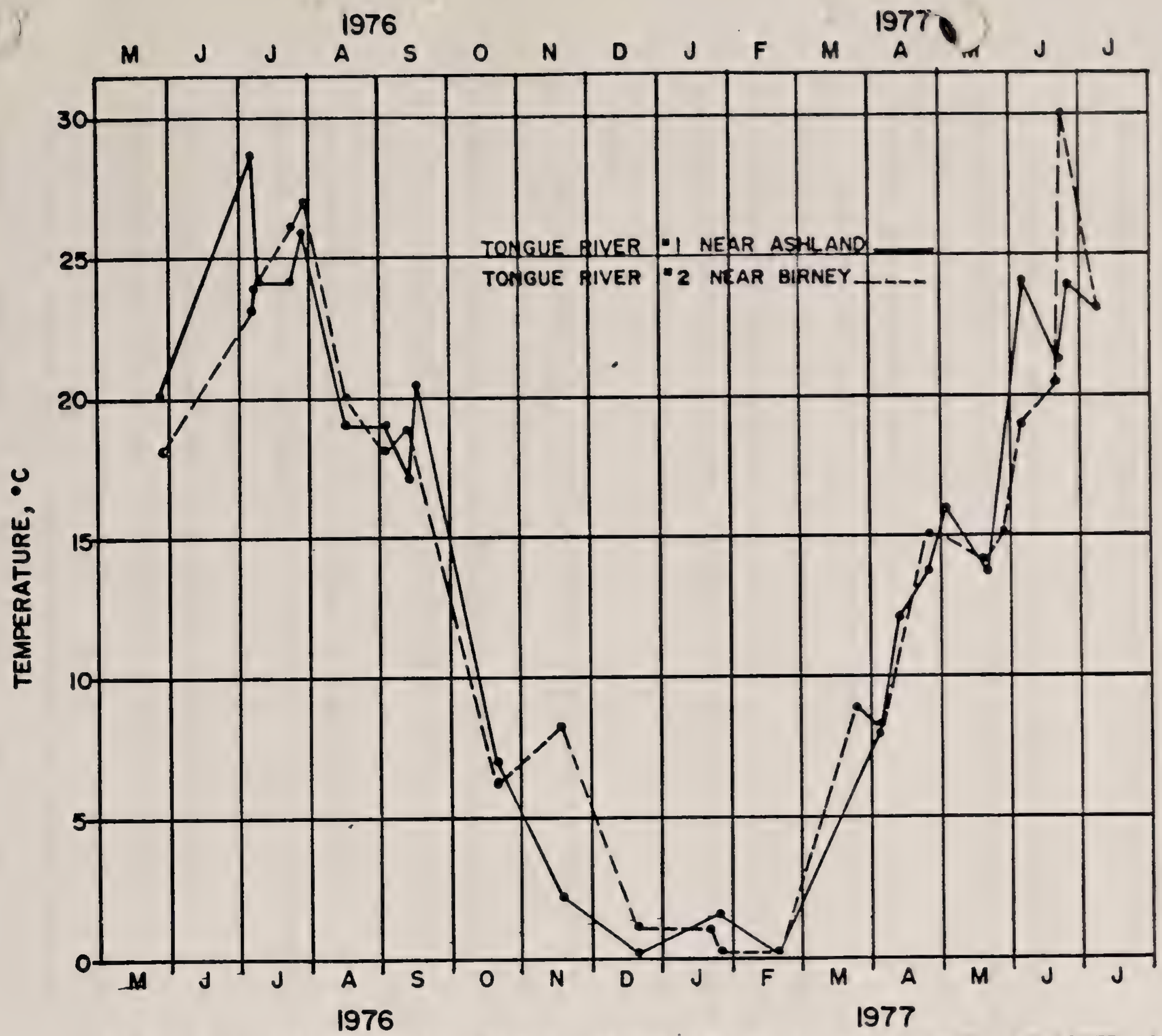


FIGURE 17 INSTANTANEOUS WATER TEMPERATURE AT THE POINTS INDICATED AND GENERAL TEMPERATURE TRENDS FOR NCRP STATIONS, TONGUE RIVER #1 AND #2.

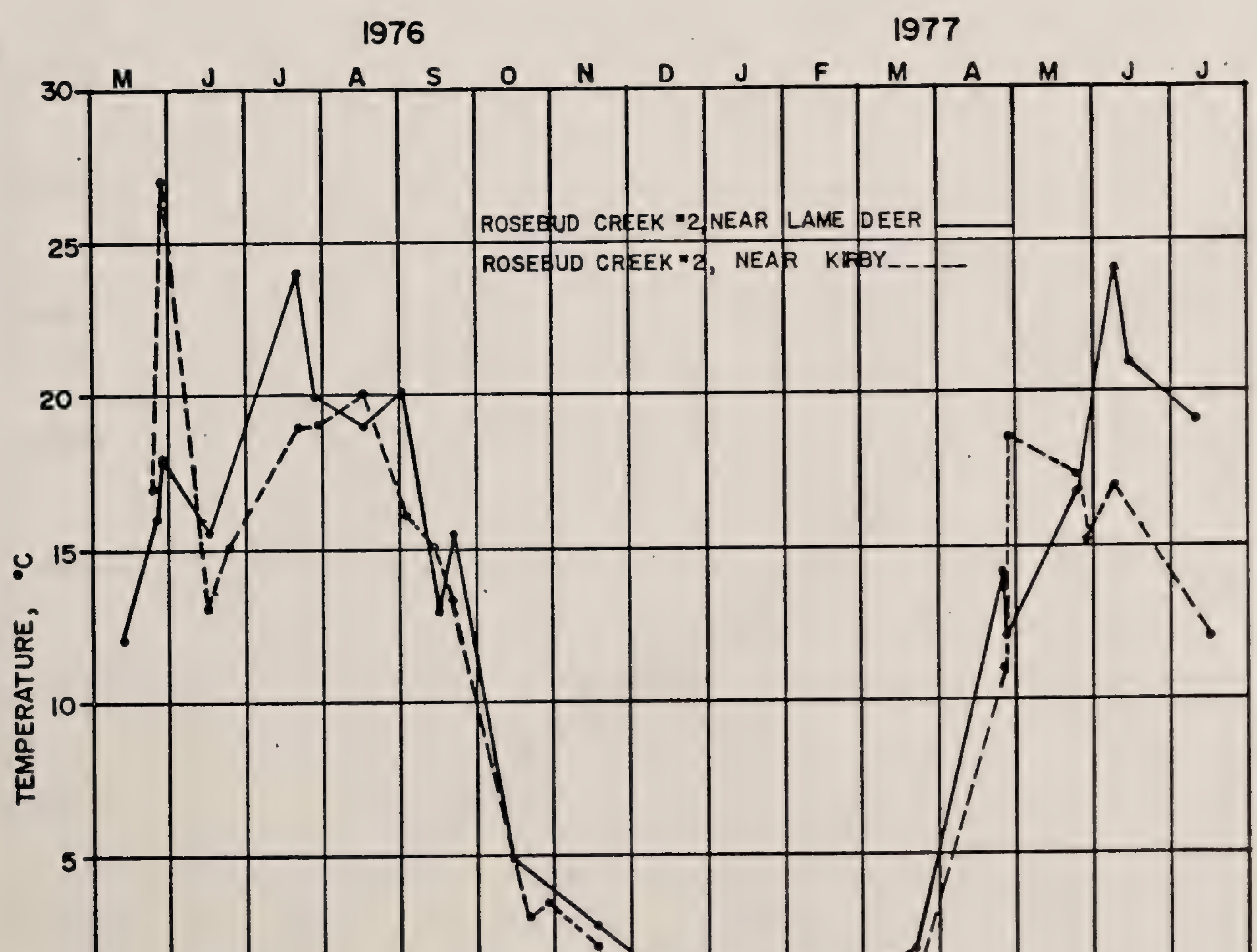


FIGURE 18 INSTANTANEOUS WATER TEMPERATURES AT THE POINTS INDICATED AND GENERAL TEMPERATURE TRENDS FOR NCRP STATIONS ROSEBUD #1 AND #2

Temperature measurements were made with a YSI T-S-C field meter.

General temperature trends appear similar between Tongue River and Rosebud Creek. Overlaying Figures 17 and 18 indicate that the Tongue River may be slower to cool down in the fall and faster to warm up in the spring. No explanation for this is offered at this time.

It is clear that more consistent and continuous water temperature data are needed if meaningful interpretations are to be made. NCRP staff is checking into the possibility of obtaining continuous temperature and conductivity recording instruments for several stations.

Additional water quality data analyses were performed by relating all lab conductivity measurements at 25°C to total dissolved solids concentrations for each monthly sample by stream sampling station and drainage. Both stations on Tongue River ard Rosebud Creek as well as each tributary were plotted separately first. Figure 19 is a composite graph of all TDS and lab conductivity values.

Yet to be done is to develop specific ion proportions for each station and relate these to conductivity. Eventually, perhaps not only TDS but also specific ion concentrations may be estimated from these relationships.

Some sediment data have been collected concurrently with streamflow measurements on the Tongue River, Rosebud Creek, and major tributaries. The samples however, were not collected with standard suspend-sediment sampling equipment as recommended by the Federal Inter-Agency Sedimentation Project.[5] Although such equipment was not available to the NCRP in the past, it will be soon received and utilized in a continuing sediment sampling program. Past samples taken with only a plastic two-quart container will be calibrated with the results of new depth integrating samplers with velocity control nozzles. Proper adjustment of past results along with new data will permit comparisons with USGS sediment data collected in this area.

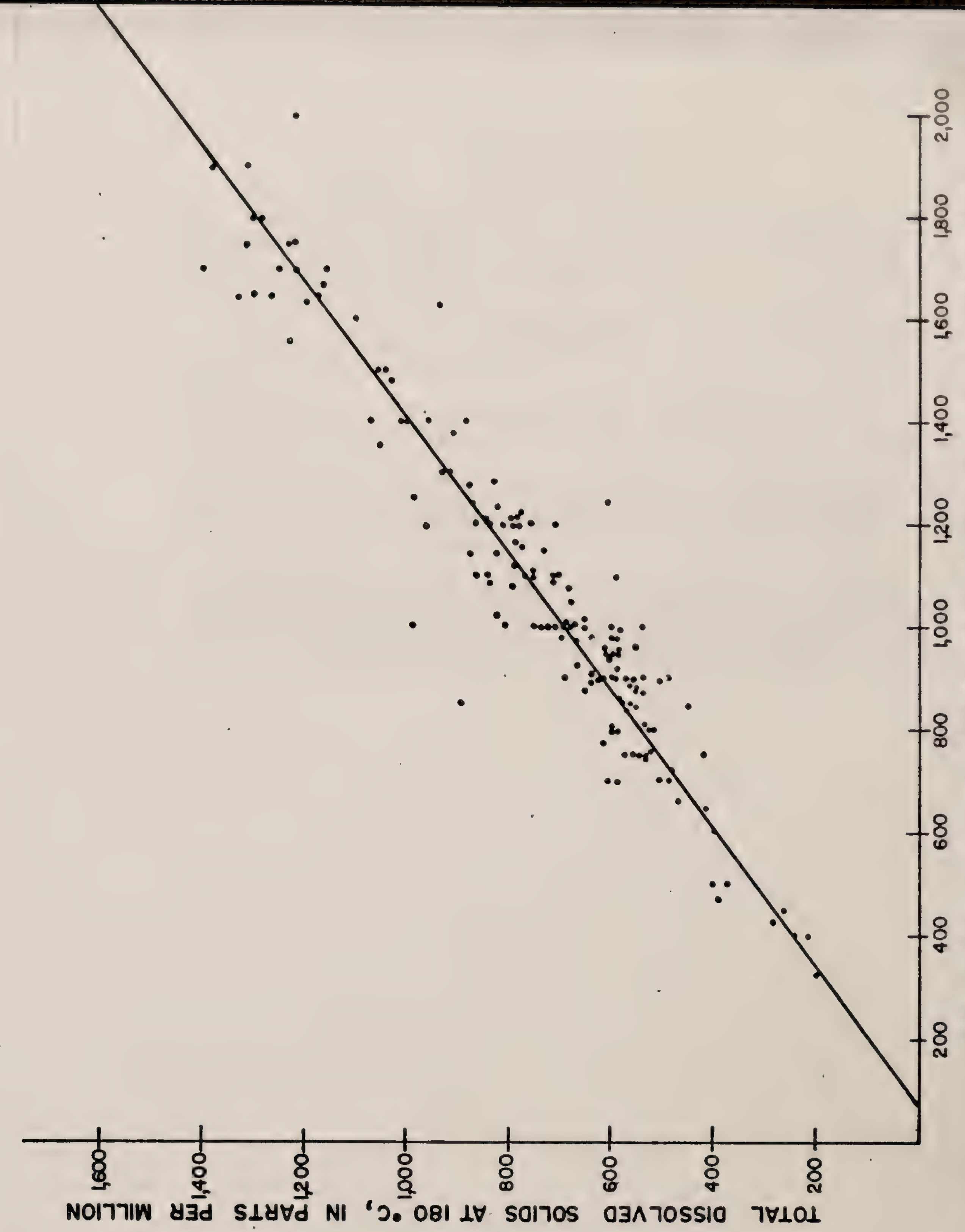


FIGURE 19 DISSOLVED SOLIDS AND ELECTRICAL CONDUCTIVITY OF MONTHLY SAMPLES OF STREA[M] WATERS ON THE NORTHERN CHEYENNE RESERVATION, DECEMBER 1975 TO MAY 1977.

Summary

It is recognized that the streamflow - water quality relationships presented here are preliminary in light of the short-term data base. Additional hydrologic and water quality data will permit more extensive analyses. It is important to define the operation of the natural hydrologic and hydrogeologic systems on and around the reservation. The Northern Cheyenne Research Project's EPA sponsored program is investigating the reservation's hydrologic budget. Hydrologic data will be analyzed in detail under the Tribal water rights litigation. The completion of these two efforts will serve as a fundamental water resource data base for the Tribe. Water resource management plans will be developed as part of the water rights case and other tribal projects such as the sprinkler irrigation project. The Northern Cheyenne Tribe will continue to monitor the quantity and quality of it's water resources to both enhance water use on the reservation and guard against degradation by off-reservation use and development.

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